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The Kent Incorporated Society for Promoting Experiments in Horticulture

IMPERIAL MYCOLOGICAL INSTITUTE
12 JUNE 1939

ANNUAL REPORT

(TWENTY-SIXTH YEAR)

1938

EAST MALLING RESEARCH STATION

EAST MALLING

KENT

1st January, 1938 to 31st December, 1938

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THE KENT INCORPORATED SOCIETY
FOR PROMOTING EXPERIMENTS IN
HORTICULTURE

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Photographer : Miss K. E. Cornford.

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* Recognized Teacher of the University of London.

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Visits may be paid to the Research Station on any weekday *by appointment* (Saturday afternoon under exceptional circumstances only).

Passenger Station : East Malling Halt (Southern Railway).

Goods Station : Aylesford (Southern Railway).

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FROM MAIDSTONE by the Maidstone and District Motor Services Limited, every 20 minutes from Maidstone to East Malling Church.

FROM LONDON a regular service of Maidstone and District Coaches from the London Coastal Service Limited, Victoria Coach Station, Buckingham Palace Road, S.W.1, may be of assistance to Visitors. The Coaches call at East Malling on certain inward and outward journeys.

For Visitors coming by road DITTON CORNER on the main London-Maidstone Road is the turning to the Research Station.

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THE IMPERIAL BUREAU OF HORTICULTURE AND PLANTATION CROPS

accommodated at East Malling Research Station.

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EDITORIAL

The Station's Annual Report is issued in two parts. That dealing with the general development and activities of the Station is published as a Supplementary Report which is presented by the Executive Committee to the Annual General Meeting ; it is mainly for the use of our Committee and Members, and is circulated separately to our Members.

The Annual Report of research work consists of four sections as follows :

I. The Experimental Farm.

II. General Review of Research Work, with Summaries of Papers published during the Year.

III. Preliminary Research Reports and Progress Reports.

IV. Bulletins for Fruitgrowers.

In the General Programme of Research work the numbers accompanying the projects are set out to correspond to those of last year. This Section includes complete lists of papers published by the Staff during 1938 together with summaries of those papers not readily available to most of our Members. Papers published in our Annual Report for 1937 are mentioned in the lists but not summarized since they are either in the hands of our Members, or can be purchased from the Station.

The general editorship of this Report has been undertaken by Dr. Wormald, but heads of Sections are responsible for the sectional reports.

R. G. Hatton.

AN APPRECIATION

M. J. R. DUNSTAN, O.B.E., M.A., F.R.S.E.

Of that happy combination of Agricultural Scientist, Landowner, and Fruitgrower, which conspired to found this institution, Mr. Dunstan was the last survivor. Notices of the deaths of Lord Cornwallis of Linton and of Mr. Frederick Smith of Loddington, have already appeared in this Journal. The passing of Mr. Dunstan in May, 1938, was a sad event not only to those who remembered him as one of the pioneers of Agricultural Education but also to the many who, during his 20 years as Principal of the South-Eastern Agricultural College, Wye, learned to value his guidance and inspiration. As the head of a famous Agricultural College he was in the position, and had the ability, to observe the trend of events and to mould the material which was so largely to shape them.

He became convinced that the time had come to apply to the great fruitgrowing area of the South-East of England the methods of scientific investigation which had already been applied so successfully to general farming at Rothamsted. Having thus decided he gathered round him a group of progressive fruitgrowers and keen horticultural scientists, and with his characteristic vigour launched a campaign for the founding of a fruit experiment station in Kent. We find him addressing meetings, organizing deputations to the Board of Agriculture and fostering the growing demand for research by arranging fruit shows, packing demonstrations and conferences. Quickly receptive of the new idea and sympathetically appreciative of the technical needs, Mr. Dunstan could always make a convincing case. In November, 1912, when the negotiations for acquiring the first 23 acres of land on recognized fruit soil at East Malling for the new Wye College Fruit Experiment Station were practically complete, he addressed a gathering of fruitgrowers at the Kent Commercial Fruit Show in Maidstone on " The Scope of Scientific Research in Fruitgrowing ". This paper was fully reported in the " Fruitgrower " and is worthy of careful study in the light of the subsequent development of East Malling's research programme. It is typical, not only of his foresight but of his racy and fluent style which always roused his audience to enthusiasm. It ended with a sentence which we hope still serves as the Station's slogan to-day in its relations with the Fruit Industry : " We have not the ability or desire to teach the commercial fruitgrower or farmer his business as a whole, we can merely touch such parts as are generally agreed can be aided by systematic scientific investigation. Our results will be offered you for criticism, acceptance, or rejection, and we would only ask that your attitude towards them in the future should be, as it has been in the past, one of critical but friendly co-operation."

Mr. Dunstan saw to it that the infant Station carried on its essential activities and survived the Great War, and when subsequently it grew up so rapidly and, on the suggestion of the Ministry of Agriculture, gained its independence as " The Kent Incorporated Society for Promoting Experiments in Horticulture ", he was amongst the first to wish East Malling Research Station well and he continued to show his interest therein by his presence on important occasions.

Mr. Dunstan has influenced the development of East Malling in a less obvious, though no less real, way. Many of its staff were his students and served under him at Wye, and they were privileged to experience that very quality of " critical and friendly co-operation " in Mr. Dunstan himself, which imbued with such a special and enduring value their relationship with him.

He had the invaluable gift of encouraging his juniors to have confidence and take the initiative and at the same time of convincing them that he took a personal interest in each individually and was always available for advice and encouragement.

[*Photograph by Elliott & Fry, Ltd.*

M. J. R. Dunstan, O.B.E., M.A., F.R.S.E.

Principal of the South-Eastern Agricultural College, Wye (1902-1922), and of the Royal Agricultural College, Cirencester (1922-27).

Section I

THE EXPERIMENTAL FARM

Contributed by J. AMOS, F. H. BEARD, R. J. GARNER, M. H. MOORE and A. C. PAINTER with an introduction by R. G. HATTON

INTRODUCTION.

This section of our Annual Report was introduced in 1930. It appears to have served the purpose of keeping many of our grower Members interested in the developments on the farm, and of helping them to visualize something of what it means to run a fruit farm experimentally. Incidentally, many of them have stated that they have found some of the experiences herein described valuable even though they deal with somewhat exceptional conditions.

The land farmed by the Institute for experimental purposes is now approximately 160 acres, including Kiln Field (18 acres) and Deadman (12 acres)—owned by the Trustees of our Development Fund—and Merryweather, a field of 10 acres, adjoining our nursery ground, and recently obtained by them on lease.

Approximately 100 acres—Great East Field (22 acres), Egham Field (40 acres), Church Field (20 acres), together with Kiln Field—lie to the west of the Ditton-Kiln Barn parish road, and, apart from the considerable area now occupied by buildings, approaches and numerous headlands (totalling some fifteen acres on the whole farm) are fully planted up with apple, pear, plum and cherry orchards now reaching maturity. Some 9 acres are given over to the hop garden.

Although these orchards are now capable of producing a considerable crop of fruit, it must be remembered that they contain many " uncommercial " varieties and rootstocks, which it has been necessary to plant for experimental purposes, and that these orchards are cut up into many different pruning, manuring, cultural and spraying treatments and untreated plots so that they cannot all be expected to yield uniformly satisfactory results. In fact, very few of the treatments represent our ideal, and our Members have now learned not to expect to see " everything as it should be " on a research farm. It is rather the function of educational authorities to give such demonstrations of the latest approved findings which are to be deduced from the investigations at the Station.

In addition to all this, it should be remembered that the Station must keep a considerable and regular labour staff, not only to get the experimental treatments carried out at the crucial moment, but also to cope with the ever-increasing crops which have to be harvested by such a long process. Although, in many instances, we have learned to rely on sampling methods to obtain our data, it will be appreciated that a few samples off a twenty-year-old tree amount to far more than the whole crop off a ten-year-old one. For instance, the problem of measuring the productivity of standard cherry trees with any degree of accuracy is a comparatively new one. It is the same with all our other records of girth, number and weight of prunings, blossom

counts, fruit drops and the final harvest. Too often we have regretted the omission of observations upon one or other of these phases of the tree's response. We now have always to be equipped with the necessary labour for carrying them out. There should be at least another twenty years over which valuable experimental data should be accumulated. What is the profitable life of an apple or cherry orchard, for instance, properly tended throughout ? And what are the omissions leading to deterioration ?

The remaining 60 acres to the east of the parish road has so far not been developed for permanent orchards in the main, though Newgates Shaw (3 acres) has been planted up with some sixty varieties of walnut and a collection of cobs and filberts. Newgates Field (25 acres) is owned by the Station, and has been used for small fruit experiments and nursery work, but the development of adjacent quarrying activities has now rendered much of this land unsuitable for the former at least. Deadman (12 acres), purchased by our Trustees, has some 4 acres occupied with plum die-back studies, but the rest is used for nursery work. Upper Grub (10 acres), Newgates Shaw (3 acres) and Merryweather (10 acres) are all held on lease. Apart from a small isolation garden of clonal Golding varieties of hops, Upper Grub has been occupied with nursery work and with intensive nursery trials of new rootstocks which are yielding very valuable results, but are of course quite unprofitable. Merryweather, which has recently been acquired, will also be used mainly for nursery operations though some 4 acres were already planted up with Cox's Orange Pippin and Worcester Pearmain on No. IX rootstock. These trees are being recorded so that they will eventually become available for investigational requirements. The experiments in large scale strawberry runner raising which were the result of an insistant demand for plants " rogued " for " Yellow-edge " disease, following the good performance of our clonal strain, have proved costly in ground and labour. When such operations are conducted with the experimental object in the fore-front, the economic aspect is apt to become secondary, at least in the early stages of the project. We have the consolation of having been instrumental in establishing some excellent daughter nurseries in well isolated locations.

In continuing, then, to publish this annual account of the activities, crops borne and prices realized on the experimental farm, we would ask our readers once again to remember that we are not attempting to show them how to run a commercial business but merely to interest them in our experimental experiences and to try to give them an economic aspect. From these facts then, there is something to be learned each year, if all the necessary qualifications and disabilities or " experimental exigencies " are borne in mind. We have recounted these so fully in former years that it should be unnecessary to repeat them on every occasion.

R.G.H.

FARM REPORT

CULTURAL.

Dull, mild and very wet conditions were general throughout the whole of January. Rain fell on 22 days, the total amount recorded being 2·94 inches. Frosts were almost entirely absent.

The weather during February was mainly warm and very dry. Similar conditions prevailed throughout March and some very high temperatures were recorded. Rain fell on only four days, the amount recorded being 0·5 inch.

These abnormal conditions for the time of the year hastened the growth of all fruit trees, and by the end of the month many varieties were in full bloom. The Station's blossoming records showed this to be at least three weeks in advance of the normal

time. Almost without exception all varieties of top and bush fruits were a mass of blossom and gave every prospect of a full crop. However, during April, which was again a month of drought, severe frosts on the nights of the 11th, 12th and 13th did extensive damage on many parts of the farm. In addition to this set back from frosts, dull cold spells occurred during part of the blossoming season and prevented effective pollination.

The early part of May was cold, cloudy, with winds from the north and east, and further severe frosts occurred on the nights of the 8th and 9th. Following these two frosts an examination of the trees showed in many cases that when the blossom had apparently escaped the frosts in April, many of the young fruitlets were now frozen. Towards the end of the month rainy conditions prevailed and came just at the time when the post-blossom scab spray should have been applied, with the result that some infection from this disease occurred.

Throughout June and July warm sunny weather was experienced. At this period a survey of our fruit plots on various parts of the farm showed that, whilst there was a general loss of crop as a result of the frosts, there were some partial exceptions ; certain varieties of both bush and top fruit were entirely wiped out whilst others had set quite reasonable crops. Whether these differences in crop were due to any frost resistant powers or the particular stage of the blossom at the time of the frost it is difficult to say. There appeared to be examples to support both points of view. Thus whilst certain plums such as Czar, President and Cluster Damson, appeared to be in a similar stage of blossoming as the Victoria, the former set good crops whereas only an occasional fruit of Victoria matured. Again in apples, whilst Bramley's Seedling was commonly frozen in the " tight flower-bud " stage, the variety Edward VII showed very little damage. Worcester Pearmain was a variety that also largely escaped, especially on the higher parts of the trees. With pears most varieties had their blossoms completely killed, but Conference, as in the frost season of 1935, again gave a satisfactory set. A few rows of the variety Durondeau which were in the shelter of nearby buildings also cropped, but, as in the case of Conference, the fruits when harvested were found to be seedless.

All the earlier flowering types of Black Currant, like Baldwin, Boskoop and Triple X were severely damaged, the only one to escape being Goliath, the flowers of which at the time of the frosts were mostly unopened. The effect of this was seen in crops harvested, Goliath giving the highest yield, Seabrook's Black being second in this respect.

Apart from these differences, it was also noted that a much better set of apples was frequently to be found on plots where the varieties were most mixed. On other plots it was observed that most fruit occurred on the outside rows of a plot where these were adjacent to a different variety. In both these instances " frost eye " damage on the fruits was common and this seems to suggest that the better set here was in part due to effective pollination which in turn may have induced some frost resistance to the blossoms.

On 12th August, a heavy hail storm cut and bruised much of our already light apple crop. The fruit of Lane's Prince Albert was seriously damaged and had to be marketed forthwith owing to the entrance of Brown Rot into the cut areas.

Both September and October were sunny, but with ample rainfall. November was exceptionally mild, but December was dull with severe wintry conditions towards the end, accompanied by heavy falls of snow.

An interesting feature on the farm during the past two seasons has been an attempt to increase our supply of organic material in utilizing various plant wastes by converting

them into humus. The method used is that described by Sir Albert Howard. The various plant wastes with some form of animal manure are mixed in heaps, so as to produce and maintain sufficient heat to encourage the growth of various fungi and bacteria which break down the plant tissues to form humus. On such a farm as ours, which is mainly planted to fruit, the amount of fresh green material available in bulk at any one time is limited and most of our compost heaps have been rather small and of an experimental nature, in order to test the method.

Whilst weeds, grass mowings and hedge trimmings are at hand periodically for this purpose most of the material has been strawberry litter, hop bines, and prunings. These materials have been mixed with varying quantities of fresh stable manure or London dung, and latterly town refuse has also been tried. Our experience has been that these manures have given the initial heat if some fairly fresh green material was added at the time of making, and quite good humus has resulted. Where, however, dry material, such as strawberry litter, has been used alone, the resulting product has often been variable. This is also probably due sometimes to other causes such as wrong amount of manure and wastes, not turning at the critical time, and more frequently inability to maintain the right temperature over a sufficiently long period. The largest quantity of humus from any one making has been that produced by the bines from our nine acre hop garden. The bines were cut up into 6 inch lengths and mixed with town wastes, and after a period of from six to eight months a fairly fine friable humus resulted. The coir yarn was, however, only partly broken down.

Other materials that have been tried are raspberry canes and winter prunings, but so far without success. Some means of crushing woody tissues before they are mixed might provide a solution to the disposal of the chief waste products on a fruit farm which now are consigned to the bonfire.

Although it is not possible at present to give details of the amount made from the various mixtures, or actual costs of making, the method has provided a means of returning to many of our plots much larger quantities of organic manure than has been given for some years past. Now that we are aware of some of the pitfalls, it is hoped in the near future to make a study of the economics of this method of supplying a source of plant food.

Fresh Plantings, Grubbings, etc.

Great East Field. One acre of three-year-old Royal Sovereign strawberry plants, used for the study of virus spread in the field, has been grubbed. This area will now be used for nursery trials.

Egham Field and Church Field. The only fresh plantings during the past year were one acre of clonal Royal Sovereign plants for runner raising. In addition small isolated plots have been planted with collections of Paxton and other varieties in order to provide a nucleus for new clonal races of virus-free material for which there is already a growing demand. While the two acres of Royal Sovereign plants under manurial and irrigation trials would have given further crops, it was found advisable to remove them after fruiting in order to avoid the risk of infestation from aphis to newly planted runner beds.

On plot 30, plots were sown in April with various grass and clover mixtures, and all have become well established. These should provide some information as to the best type of " Ley " for our plantations conditions and also their value for supplying humus to the soil. These " leys " are being compared with certain annual green

crops such as White Mustard, Rape, Spring Tares and Fat Hen (*Chenopodium album*).

A new plot has been earmarked for the testing of new varieties of top and bush fruits sent out under R.H.S. Wisley Fruit Testing Scheme and the following varieties were planted last spring: Plums: Marjorie's Seedling, Bountiful and Delicious; Apples: Arthur Turner, Crawley Beauty, Fortune, Epicure and Woolbrook Pippin. Some of the twelve-year-old trees of apple varieties originally sent out under the above scheme and since discarded have been frameworked to some of the best of the new apple seedlings raised at this Station. This method promises to provide a quick way of obtaining fruit of new introductions in bulk and so to enable their market qualities to be tested at an early period.

On some of our older pear plantations preliminary trials of dehorning of certain varieties like Pitmaston gave promising results by increasing the set of fruit, and a further series of trials has been started in which some 18-year-old trees of Conference and Pitmaston have been dehorned.

Newgates Field. Owing partly to the spread of mosaic, and also to dust nuisance from a nearby stone-crushing plant, the remaining $2\frac{1}{4}$ acres of seven-year-old Lloyd George raspberries have had to be grubbed. The five acres of Royal Sovereign strawberries planted in 1936 were used for raising a second batch of runners and, owing to the promising amount of blossom in spite of the frosts, were allowed to fruit. Immediately the fruit was picked the plants were ploughed in and a green crop of oats and tares was sown. This green crop was later ploughed in together with a light dressing of dung, and the whole area again replanted with strawberry runners. The plants have been spaced at varying distances in order to find out the most economical way of raising the greatest number of saleable runners per acre.

Upper Grub. Only a few small areas were available for planting and these were all filled with Royal Sovereign plants for runner production.

A small bed of our clonal selections of Goldings Hop varieties was again planted with cuts in order to increase our stock for future plantings.

Kiln Field. Some 120 trees of twenty-four-year-old Gladstone apple trees were frame-worked in various ways with Cox or Worcester as the scion variety.

Deadman. Royal Sovereign runners were raised on the six acres from maiden plants planted in the previous October. All these runners were distributed in the autumn, the parent plants removed, and the whole area dunged and ploughed. This piece has now been replanted with the same stock and will be kept for fruiting. Three acres at the south end under young plums has been filled in with bedded apple stocks.

Merryweather. The four acres planted with Cox and Worcester on No. IX rootstock has been interplanted for one season with Royal Sovereign plants for runner production. The open four acres was spring planted with Royal Sovereign plants, and from this area runners have been reserved for spring delivery.

(J.A.)

PROPAGATION.

Stoolbeds. (Area under cultivation about 10 acres.) The production of rooted layers was well up to normal, and rooting was excellent in spite of the prolonged spells

of dry weather earlier in the growing season. On the other hand, the bedded stocks suffered severely, particularly those which were planted at the end of the dormant season. Late planted material may do reasonably well provided moist conditions prevail throughout spring and early summer, but when late planting is followed by early drought losses are likely to be very severe.

About four hundred thousand rootstocks were raised during the year. For the first time in the history of the Station's commercial stoolbeds orders for rootstocks did not, in all cases, exceed the supply. Stone-fruit rootstocks were in good demand; we could easily have sold ten times as many cherry rootstocks as were available. Large quantities of Quince A also sold very readily but the apple rootstocks were only applied for in limited quantities by home growers and we have had to retain fairly large lots of rootstocks, particularly of the very vigorous class. The rootstock No. II sold more readily than others and a few large orders from Canada for No. IX practically cleared our one time surplus of this rootstock.

We gather that this falling off in rootstock demand was general throughout the trade and is certainly due in part to unsettled trade conditions. The overseas demand for our rootstocks has increased but not sufficiently to offset the falling off of home orders. In all, some three hundred thousand rootstocks were distributed.

General Nurseries. (Area under cultivation about 12 acres). Most of this area is made up by the use of small areas of land in various parts of the Station and by temporarily interplanting permanent crops. More than half this area is occupied by material directly involved in experiments and is therefore not always immediately remunerative. This material almost always requires special treatment and is therefore more expensive to produce than that of commercial nurseries.

About fifteen thousand buds were inserted during the season, ten thousand of which are intended for the large scale commercial apple trials. The remaining five thousand were mostly for the annual demonstration nursery and for nursery technique studies. Bush fruits were not raised in large quantities.

Strawberry Runners. (Area under cultivation 12 acres.) During the spring about one hundred thousand clonal Royal Sovereign and thirteen thousand clonal Tardive de Leopold plants were distributed from our own nurseries and we assisted in the distribution of one hundred and fifty thousand from our daughter nurseries. In the autumn we sent out over three hundred thousand clonal Royal Sovereign runners from plots at the Station. Thus we sold well over half a million plants during the year. One hundred and twenty thousand plants remain in the beds for spring lifting. Even with an output of seven hundred thousand plants we were unable to fulfil all the orders received. (R.J.G.)

Marketing.

The severe frosts experienced in April and May seriously affected all kinds of fruits both as regards quantity and quality. Hail also did considerable damage to the later varieties of apples. Fruit quality in consequence was poor. Prices, however, all things considered, were good, though, except for certain varieties of apples, did little to compensate for the lack of crops.

Gross receipts from the 1938 crop amounted to £3,200 as against £5,200 in 1937. The approximate quantities sold during the year and the average prices received were as follows :—

	1937 Crop.	£	Average Price. s. d.
Apples (Gas Stored)	1,490 bushels	710	9 6 a bushel
	1938 Crop.		
Strawberries	3¾ tons	214	6 a lb.
Raspberries	2½ ,,	120	5 ,,
Red Currants	2¼ ,,	90	4¼ ,,
Black Currants	2½ ,,	192	8 ,,
Loganberries	1¼ ,,	61	5¼ ,,
Blackberries	1 ,,	41	4½ ,,
Gooseberries, peaches, etc.	—	14	—
Cherries (Acid)	½ ,,	25	5½ ,,
Plums	1,300 half sieves	435	6 8 a half sieve
Pears	280 bushels	100	7 2 a bushel
Apples	5,100 ,,	1,905	7 6 ,,

Unless otherwise stated prices are gross and those obtained for the main crop. Odd consignments at the beginning and end of the season are not as a rule taken into account.

A table showing the quantities of marketable fruit obtained from some of the more common varieties of apples, pears, and plums on certain plots between 1935 and 1938 is given below, as, though other factors must also be taken into account, it is thought to give a very fair idea of the extent to which frost affected these different varieties at the Research Station.

Conditions prevailing in each of these years will be readily called to mind, viz. :—

1935. As a result of frost experienced on the night of 16th May there was an almost complete loss of crop of all top fruits.

1936. There was a full crop of nearly every variety.

1937. Crops, after the heavy yields of the previous year, were nearly all light.

1938. From the appearance of the blossom there appeared to be every prospect of a year of heavy crops, approximating to that of 1936. The principal cause of subsequent failure was undoubtedly the severe frosts experienced during April and early May.

It should be made quite clear at the start that the crop of one variety cannot be compared as it stands with that of another in any one year, as the age of the trees and acreage under cultivation differ in each instance. The comparison that has to be made is the relative reduction in crop between 1936 and 1938.

It will at once be seen that there were marked differences between the various varieties. As regards apples, whilst there was little reduction in the case of Lord Derby and Edward VII, with Bramley's Seedling and Cox's Orange Pippin the crop in 1938 was less than one eighth of what it was in 1936. Worcester Pearmain, Allington Pippin, Grenadier, and Lane's Prince Albert all cropped moderately well in 1938, the reduction as compared with 1936 being less than 50%.

In the case of pears, the frost resistant properties of Conference are well brought out, this variety having an appreciable crop in both 1935 and 1938. With the exception of Hessle no other varieties cropped in either of these years.

With plums the main point of interest was the complete failure of Victoria whilst Czar did well after cropping heavily for two years in succession. That Czar is more

frost resistant than most varieties would seem to be confirmed by the fact that in 1935 it was the only variety to set any measurable quantity of fruit. Two other varieties to crop well with us in 1938 were Cluster Damson and President.

Comparative crops of marketable fruit of certain varieties of Apples, Pears and Plums, 1935-1938.

Apples (in bushels).

	1935.	1936.	1937.	1938.
Worcester Pearmain	5	1,480	1,290	870
Allington Pippin	Nil	260	120	140
Cox's Orange Pippin	1	630	240	70
Grenadier	5	500	80	390
Lord Derby	10	730	560	720
Lane's Prince Albert	20	2,420	380	1,120*
Bramley's Seedling	20	4,900	1,250	600
Edward VII	12	300	160	290

* Owing to hail, picked 3 to 4 weeks earlier than usual. Had it been picked at the normal time it is estimated that the weight might well have been as much as 20 per cent. greater.

Pears (in bushels).

	1935.	1936.	1937.	1938.
Conference	140	370	75	160
Dr. Jules	5*	190	11	20*
Souvenir du Congres	Nil	130	8	Nil
Hessle	1	50	24	36
Doyenne du Comice	Nil	23	Nil	3
Beurré Clairgeau	Nil	85	1	11
Beurré Hardy	Nil	70	Nil	2

* A large proportion of these were secondary fruits.

Plums (in half-sieves).

	1935.	1936.	1937.	1938.
Rivers' Early	Nil	190	270	15
Czar	50	750	730	280
Victoria	Nil	1,470	610	30
Pershore Egg	Nil	260	200	60
Damsons (Cluster)	Nil	140	25	110
Warwickshire Drooper	Nil	75	70	25
President	Nil	32	200	180

Individual Crops.

Strawberries. (Area under cultivation—Approximately 2 acres of experimental plots in Egham Field and Great East in their third year. Also 3½ acres in Newgates Field, which had been used in 1937 for runner production.)

In spite of the frost, which it is estimated destroyed approximately 40% of the blossoms, some 2¼ tons of marketable fruit were picked from the plots in Egham and Great East.

The yield in Newgates Field was considerably lighter, as was to be expected from plants which had already been used for runner production, amounting to some 33 cwt., or 9½ cwt. to the acre.

As it was the early blossom, which usually produces the largest berries, that had been destroyed, the fruit was small, only 28% reaching National Mark Standard.

Selected fruit was marketed in 2 lb. climax baskets, and fruit under National Mark Standard as " smalls " in shallow 4 lb. chip baskets.

Prices, which were high considering the quality of the fruit, were as follows :—

Selected (National Mark) between 1s. 6d., at the beginning of the season, and 6d. a pound, with an average of 9¼d.

Smalls between 10½d. and 3d. a pound, with an average of 5d.

Raspberries. (Area under cultivation—About 2½ acres of five-year-old Lloyd George and 1 acre of four-year-old new seedling varieties in Newgates Field. Also small patches of new seedlings and odd varieties in Egham Field.)

In common with many plantations throughout the country the Lloyd George wintered badly ; the cane was extremely poor and made little growth of any description, the absence of lateral growth being very marked. This, coupled with the frosts and damage from dust from a nearby quarry, had the effect of reducing the crop to very small proportions, only some 32 cwt. being picked from the 2½ acres. Moreover, quality was poor and the fruit only fit for jam. The gross receipts from this plot amounted to £65, an average of 4¼d. a lb.

The acre of new seedling varieties, though also badly affected by frost, did better, yielding nearly a ton of fruit. Of this :—

17% was marketed in 3 lb. chips under the National Mark at an average price of 9d. a lb.

35% in 3 lb. chips as Grade 1 at an average price of 6¼d.

48% in tubs for jam at an average price of 4¼d.

The average price for all grades was 6d. a lb.

Black Currants. (Area under cultivation—2 acres of six-year-Baldwin and Wellington Triple X, 2 acres of five-year-old mixed varieties in Newgates Field, and 4 acres of five-year-old Wellington Triple X interplanted with plums and cherries in Church Field.)

The black currant crop was poor, the yield from the 8 acres only amounting to a little over 2½ tons, or an average of 6½ cwts to the acre.

Though the sample was not a good one prices were high in view of the general scarcity, ranging from 7½d. to 9d. a lb., and averaging 8d.

The fruit was marketed in 4 lb. chips.

Red Currants. (Area under cultivation—A variety and cropping trial comprising ¾ acre of seven-year-old bushes interplanted between pears in Egham Field.)

Red Currants suffered far less severely from frost than most crops, the variety plot yielding 2 tons 6½ cwt., or over 3 tons to the acre. Prices ranged from 3d. to 6d. a lb. and averaged 4¼d., the later varieties generally speaking commanding the better

prices. Wilson's Longbunch, already referred to in previous reports, again did well, averaging 5d. a lb.

The fruit, as usual, was marketed in 6 lb. chips.

Loganberries and Blackberries. (Area under cultivation approximately ¾ acre in Church Field).

The Loganberry crop amounted to approximately 1¼ tons. National Mark Selected fruit, which comprised about 45% of the crop, sold at an average price of 6¼d. a lb. The remainder averaged 4¼d.

Rather under a ton of blackberries were marketed at an average price of 4½d. a lb. The quality however was not good, much of the fruit being marked by hail.

Cherries. (Area under cultivation—⅖ acre of fifteen-to seventeen-year-old Morellos, planted at 12 by 12 ft., ½ acre of twelve-year-old Morellos, ⅔ acre of eleven-year-old Kentish Red and ⅓ acre of Carnation and young Morellos, all at 15 by 15 ft., in Egham Field. In addition ¼ acre of ten- and eleven-year-old Morellos in Newgates Field held at the disposal of the Pathology Section for spraying trials. A miscellaneous variety collection of sweet cherries in Egham Field, and a stock trial comprising 6 acres of eleven-year-old Early Rivers, Schrecken, and Turk, interplanted between plums and black currants at 30 ft. apart in Church Field.)

The cherry crop was negligible, consisting of 7½ cwt. of Morellos and 2½ cwt. of Kentish Red. There were not sufficient sweet cherries to make picking worth while.

Plums. (Area under cultivation—3-acre plot of sixteen-year-old trees in Egham Field; also 2 acres of thirteen-year-old trees interplanted with cherries. In Church Field 2½ acres of ten-year-old trees interplanted with cherries and black currants, ½ acre of Czars and Myrobolans planted for windscreen purposes in Egham and Newgates Field. Also 3 acres of seven- to eight-year-old Giant Prune in Deadman.)

Apart from Cluster Damson, which cropped well, and Czar, Giant Prune, and President, which gave moderate yields, the plum crop was extremely light. Victoria, which with Czar usually provides the bulk of fruit, failed completely. No fruit thinning was done.

Generally speaking quality was not good. Russeting, believed to be due to frost, was very prevalent, and this necessitated a considerably greater quantity of fruit than usual being relegated to the "Second Quality" (i.e. blemished) grade.

Prices on the other hand were good, those obtained for some of the main varieties being given for comparison with last year :—

	National Mark. Equivalent per half-sieve of 24 lb.						Lower Grade. Equivalent per half-sieve of 24 lb.					
	s.	d.		s.	d.		s.	d.		s.	d.	
Rivers' Early	8	6	to	10	0		6	0	to	8	0	
Czar	5	0	,,	10	0		3	6	,,	9	0	
Purple Egg	5	6	,,	6	0		4	0	,,	5	0	
Pershore Egg	5	0	,,	5	6		4	0	,,	5	0	
Victoria	10	0	,,	14	0		6	0	,,	9	0	
Giant Prune	5	0	,,	12	0		4	6	,,	7	0	
Warwickshire Drooper ..	9	0	,,	20	0		5	0	,,	7	6	
President	6	0	,,	12	0		6	0	,,	9	0	
Damsons				8	0	to	4	6				

There was not sufficient fruit to cold store, the entire crop being marketed straight from the tree.

The good impression given by Warwickshire Drooper in previous years has been fully maintained. For those reading this report for the first time it may be repeated that this variety ripens in mid-September (when mid-season plums, such as Victoria and Giant Prune, are mostly off the market) has an attractive yellow colour, often mottled red where exposed to the sun, and so far here has both cropped well and commanded a satisfactory price ; it also keeps well in cold store. The approximate average crops of the set of 19 trees grown at the Research Station (now 16 year planted) and prices obtained since 1934 have been as follows :—

	Average crop of Marketable Fruit per tree in half sieves.	Average gross price per half sieve. s. d.	Remarks.
1934	3	7 0*	
1935	Crop destroyed by frost.		
1936	4½	6 3*	Good deal of sooty blotch.
1937	4	7 6*	
1938	1½	12 5	Crop much reduced by frost. Price probably rather in the nature of a fancy one.

* In these years a portion of the fruit was cold stored. Had the whole crop been marketed direct from the tree it is estimated that the average price would have been 6d. to 9d. a half sieve less.

Whilst it is fully realized that the quantities dealt with have been small, from the experience we have gained of this variety and the generally favourable reports we have received from the markets, we consider that it is one well worth a trial. One word of warning, however, is necessary—there are apparently two kinds of Warwickshire Drooper grown and care must be taken to obtain the right one.

The quantities marketed and average prices obtained for a number of varieties is given in the Appendix.

Approximately two-thirds of the crop was marketed in 12 lb. chips, and the remaining one-third in half sieves.

In all the equivalent of 540 half sieves was sold under the National Mark or 50% of the crop of those varieties allowed to be marketed under the scheme.

Pears. (Area under cultivation—6 acres in Egham and ½ acre in Church Field, five of which consist of a number of different varieties from twelve to nineteen years of age. The other acre, consisting of ten-year-old trees, is just coming into bearing.)

Pears were again a light crop, the total quantity of marketable fruit only amounting to some 280 bushels.

Our experience with pears was much the same as in 1935. The only variety to prove frost resistant to any extent was Conference which yielded approximately 160 bushels, though there was also a certain quantity of Hessle and Durondeau. As in that year the centres of the fruits that survived were in nearly every case blackened and seedless and the fruit small and of poor shape.

Conference fetched from 5s. od. a bushel to 5s. od. a half sieve according to size and quality, but, as the fruit had to be marketed during crisis week in September, it undoubtedly fetched less than it otherwise would have done.

What little fruit there was of other better class varieties fetched from 3s. 6d. to 6s. od. a half sieve, and Hessle from 4s. od. to 7s. od. a bushel.

Apples. (Area under cultivation—23 acres in Great East, Egham, and Church Fields, consisting of many different varieties from eight to twenty-four years of age. Also 14 acres of approximately twenty-two-year planted trees in Kiln Field, and five acres of four-year-old trees in Merryweather ; the latter, however, have not yet come into bearing.)

1937 *Crop.* Some 1,500 bushels of Bramley's Seedling, Edward VII and Lane's Prince Albert, which had been gas stored in the autumn, were marketed between 23rd March and 13th April.

Fancy Lanes, fetched from 8s. to 10s. a bushel, Bramley's from 8s. to 12s. and Edward VII from 8s. to 11s.

Domestic standard fetched anything from 6d. to 2s. 6d. a bushel less than Fancy, and Second Quality from 1s. to 3s. 6d. less. (See also under Storage Notes.)

1938 *Crop.* There was an extremely good show of blossom but like everything else apples suffered severely from the frosts, though the crop was larger than at one time seemed probable, amounting in all to rather over 5,000 bushels, or approximately the same as in the previous year. Of the main varieties, Early Victoria, Grenadier, Worcester Pearmain, Lord Derby, Lane's Prince Albert, Allington Pippin and Edward VII gave fair to good crops. On the other hand Beauty of Bath, Miller's Seedling, Cox, Bramley's Seedling (our main variety), and Blenheim, failed almost completely.

In the case of Early Victoria, Grenadier, Worcester Pearmain, Lord Derby and Lane's Prince Albert crops were heavy enough in places to necessitate a fair amount of thinning. Where possible Early Victoria, Lord Derby, and Lane's Prince Albert were thinned to six inches apart, but otherwise for experimental reasons thinning was mainly confined to reducing the fruit to singles.

Frost seriously affected fruit quality, in many cases quite spoiling its appearance. This damage varied from severe russeting to a slight roughness of the skin, some varieties being much more affected than others. Here the damage appeared to be worst with Bramley and Cox, but was also severe in the case of Beauty of Bath, Worcester and Allington. Edward VII suffered to a lesser extent, whilst Early Victoria, Grenadier, Lord Derby and Lane's Prince Albert were little affected.

Further damage was caused by a hailstorm of some severity which passed over a part of the Research Station on 12th August. Lane's suffered most, but much damage was also done to Bramley's, Cox, Allington and part of the Worcester crop. Lord Derby and Edward VII on the other hand largely escaped. The greater part of the Grenadiers and earlier varieties had already been picked.

For these two reasons the quality of most of the fruit left much to be desired, as evidenced by the low proportion of fruit reaching National Mark standard.

As in the previous year there was a good deal of bitter pit and lenticel spot in certain varieties, such as Newton Wonder, Allington and Cox. This is thought to be mainly due to the light crops but, as an increasing number of enquiries are reaching us on this subject, it may be as well to state the present position. Though a good deal of work in this connection has been done, especially abroad, comparatively little seems to be known either as regards the cause of these troubles or as regards their prevention or cure. The present extent of our knowledge may be briefly summed up by saying that generally speaking large fruits, fruits from young trees, "king" apples, in fact any coarse nitrogenous fruits, seem more prone to this sort of trouble than others. It is far more prevalent when crops are light and in some cases is associated with moisture conditions. Again certain varieties, such as Newton Wonder, Allington, and often Cox, appear to be definitely more susceptible than others. Though at the moment there seems to be no satisfactory control it is at any rate thought that care should be taken not to overfeed with nitrogenous manures varieties that may be susceptible, and to avoid as far as possible anything that tends to produce a coarse nitrogenous type of fruit. Those who would like to study the matter further are referred to an "Annotated Bibliography of Bitter Pit" prepared by the Imperial Bureau of Fruit Production in 1934 and obtainable from the Imperial Bureau of Horticulture and Plantation Crops, East Malling Research Station, Kent (price 1s. 6d.).

The frost and hail damage necessitated some change from the ordinary marketing programme. There was not sufficient fruit to make it worth while using the gas stores, and the greater part of the crop was marketed straight from the tree, only some of the later varieties being held over for a time in cool store.

The Lanes, which it had been hoped to gas store, were picked shortly after the hail, i.e. three to four weeks earlier than usual, as it was feared that there might be abnormal loss from brown rot attacking the damaged fruit. Though this involved a loss in size of fruit and weight of crop it is not thought that there was any monetary loss, as prices remained good throughout the period of marketing, only dropping towards the very end. Had the fruit been picked and marketed at the normal time a lower price would undoubtedly have been received.

In the case of Bramley's and Newton Wonder, all Fancy and Domestic fruit over $3\frac{1}{2}$ ins. in size, which does not normally keep well, and all Second Quality (i.e. Cull) fruit, as much of it was very rough, was marketed at once; with Bramley this represented nearly 40% of the crop. The Fancy and Domestic fruit made from 7s. 6d. to 10s. a bushel, whilst the Second Quality (of $2\frac{1}{2}$ inches and over) from 5s. to 9s. As by Christmas the price of Fancy fruit between $2\frac{1}{2}$ to $3\frac{1}{2}$ inches had risen to between 11s. and 14s. a bushel, and Domestic to between 8s. and 13s., it would probably have paid to have held it for a time, but it is not always easy to foretell the trend of the market and it is very easy to be wise after the event. In a normal year with a larger quantity of fruit on the market the course taken would in all probability have been the right one.

Cox with us were not only a light crop but, for the reasons already given, of very poor quality, only some 8% reaching Fancy standard and as much as 45% having to be relegated to the Second Quality grade. Owing to its condition it had mostly to be marketed in November, the Fancy fruit making from 11s. to 11s. 6d., Domestic from 7s. to 10s. 6d., and Second Quality from 6s. to 8s. 6d. a half sieve. It thus missed the sharp rise in price that took place towards Christmas. A few half sieves of Domestic standard of no particular quality marketed at this time made as much as 13s. to 15s. a half sieve.

Prices were good, the following being some examples :—

Miller's Seedling (over 2 in.).—Fancy grade from 4s. 6d. to 6s. a half-sieve. Others 3s. to 4s. 6d.

Worcester Pearmain (over 2 in.).—Fancy grade from 8s. to 14s. a bushel. Others from 4s. to 11s.

Allington (over 2 in.).—Fruit below Fancy grade from 4s. to 10s. a bushel.

Early Victoria (over 2 in.).—Fancy from 5s. to 8s. 6d. a bushel. Others from 4s. to 6s. 6d.

Grenadier (over 2¼ in.).—Fancy from 5s. to 9s. a bushel. Others from 4s. to 7s. 6d.

Lord Derby (over 2¼ in.).—Fancy from 5s. to 10s. a bushel. Others from 4s. to 7s. 6d.

Lane's Prince Albert (over 2¼ in.).—Fancy from 6s. to 10s. a bushel. Others from 5s. to 8s.

Bramley's Seedling (over 2½ in.).—Fancy from 10s. to 14s. a bushel. Others from 5s. to 13s.

The yields and average prices obtained for a number of varieties are given in the Appendix.

The total quantity of fruit reaching National Mark Standard was 1,840 bushels or approximately 40 per cent. of the crop of those varieties allowed to be marketed under the Scheme, as against a normal 60 to 70 per cent.

Storage Notes.

Gas Storage.

In the early part of the year one of the gas storage chambers was employed to gas store some 1,500 bushels of Bramley's Seedling, Lane's Prince Albert, and Edward VII of the 1937 crop.

Conditions were not altogether favourable for storing. There was not sufficient fruit to fill a chamber, three varieties had to be mixed together, and owing to the short crop the fruit was mainly oversize. The season's working, however, confirmed the lessons of previous years, especially as regards wastage in large sized fruit. Unless it is of good keeping quality and has been stored under good conditions, it is thought wisest to keep out large sized fruit altogether. Experience here with Bramley's is that, where the fruit is of just average keeping quality, there is a tendency for wastage in apples of over 3½ inches in size to be unduly high after say 5 to 6 months' storage. If, however, it is decided to store such fruit it is best kept apart and where it can be easily removed as soon as it shows signs of breaking down.

Natural Storage.

In 1938 there was not sufficient fruit to make gas or cold storage worth while, Such fruit as it was decided to keep was placed in two of the gas storage chambers, and the engines run so as to maintain the temperature between about 40° and 43°F. This proved admirable for its purpose, such varieties as Bramley's Seedling and Edward VII being marketed in excellent condition in late December and early January.

We once again wish to acknowledge our indebtedness to Dr. Cyril West of Ditton Laboratory for his expert advice on storage matters.

APPENDIX

Approximate yields and average prices for certain varieties of Plums and Apples.

(NOTE.—Though quantities are in many cases extremely small, prices are given to enable those wishing to do so to make a comparison with previous years.)

PLUMS

Variety.	Approximate Quantity marketable fruit.	% National Mark Fruit.	Average market price per ½-sieve.	Remarks.
	½-sieves.		s. d.	
Rivers' Early	14	51	8 3	
Czar	430	21	5 4	Much russeting.
Purple Egg	33	23	4 11	Small fruit.
Pershore Egg	60	52	4 9	
Victoria	40	71	10 4	
Giant Prune	290	77	7 3	
Warwickshire Drooper..	25	76	12 5	
President	180	68	8 5	
Damsons	170	—	6 8	

APPLES

Variety.	Approximate Quantity marketable fruit.	% National Mark Fruit.	Average price per bushel picked fruit.	Remarks.
	Bushels.	1937 CROP.	s. d.	
Lane's Prince Albert ..	410	80*	8 6	380 bushels gas stored.
Bramley's Seedling ..	1,240	66	9 10	960 bushels gas stored.
Edward VII	160	77	9 9	140 bushels gas stored.
		1938 CROP.		
Early Victoria ..	130	29	5 5	Small fruit.
Grenadier	430	69	6 3	Slight hail damage.
Worcester	870	30	8 9	Much hail and frost damage.
Lord Derby	720	69	6 10	Slight hail damage.
Lane's Prince Albert ..	1,120	43	6 5	Much hail damage.
Allington	150	3	7 5	Much hail and frost damage.
Cox's Orange Pippin ..	65	8	16 3	,, ,, ,,
Bramley's Seedling ..	600	23	9 8	,, ,, ,,
Edward VII	300	40	10 3	Considerable frost damage.

* Excluding scald which developed in gas store.

(A.C.P.)

Hops.

(Area under cultivation, 9 acres; 5½ acres of Professor Salmon's seedlings in Egham Field, 3¼ acres devoted to cultural trials in Church and Egham Fields, ¼ acre of commercial varieties in Upper Grub. About 2 acres were not in full cropping.)

The cold weather in May adversely affected bine growth, more particularly where cutting had been done early or the most forward bine trained up. Bine growth throughout the season was rather below normal and only the most vigorous varieties produced " heads " over the top wire.

There were very few basal spikes of Downy Mildew, but there was a severe outbreak of lateral and terminal spikes during the first three weeks of June. This attack was probably due to wet and windy weather at the end of May, as it has been noticed before that rain accompanied by a strong wind appears to cause a rapid spread of the disease. In the absence of strong winds the spread of infection is usually less rapid.

Throughout the season " spikes " were removed promptly. Two sprayings were given with Bordeaux mixture, and the crop was picked free from Downy Mildew.

Aphides were plentiful during the early summer; two washings (13th and 18th June) cleared up the attack, but nicotine was included in the subsequent Bordeaux sprayings, as a further safeguard. The season of 1938 was particularly favourable for the spread of Mould, and whilst the routine applications of flowers of sulphur gave satisfactory control on practically all varieties, one or two seedlings with very " housy " bine were attacked on the cones.

It was once again possible to pick our entire acreage, and the total growth amounted to 6¼ tons. Yields were below normal and would have been still lower had not the hops " weighed " better than in the previous season.

The prices realized for the principal growths in 1937 and 1938 are shown in the following table. The figures for the two seasons do not show any large differences, but prices for several varieties were slightly higher in 1938, whilst only two varieties were valued at a lower figure than in the previous year. Mixed growths other than those of the Manitoba and New Mexican type were, however, lower by 25s. in 1938.

Variety.	No. of pockets.	Price per cwt.	
	1938.	1937.	1938.
		£ s.	£ s.
Brewer's Gold (C9a)	½	11 0	10 10
Bullion Hop (Q43)	½	10 0	10 10
P13	3	10 0	9 15
Cats' Tails (OZ79)	½	10 5	10 10
O147 (New Mexican seedling)	4¾	9 10	9 15
Quality Hop (OO63)	6	9 10	9 10
Brewer's Favourite (OP21)	7	9 0	9 5
Fillpocket (Z62)	3	9 10	9 10
Fuggle	7¾	8 10	9 0
New Mexican and Manitoba seedlings ..	—	8 10	8 10
Other Mixed Growths	—	8 5	7 0
OV7	5½	7 0	7 10

(F.H.B.)

Routine Spraying Programme.

Although frost destroyed much of the crop, the routine spraying programme was, in general, not appreciably reduced. This policy was followed because it seemed desirable to preserve the greatly enhanced potential value of such light crops as there

were, and to avoid a possible accumulation of pests and diseases for another year.

Bad weather, including rain, frost, fog, and snow, prevented a start being made with the tar-oil spraying before Christmas, and even afterwards it was imperative to do a little at a time when weather conditions permitted. Tar-oil was omitted on a few plots of established apples to see whether this might occasionally be done without undue risk. A little aphis was seen later on these plots ; this was not at all severe, but it was indicative that omission of tar-oil prolonged for more than one winter might be unwise.

The year was noteworthy for an extremely early blossom period. Summery weather occurred all March until the latter end, and blossom periods for most crop plants were advanced by three or four weeks. This greatly influenced the spring spraying programme, and telescoped the period available for pre-blossom spray-applications. It will be seen that, in consequence, pears were sprayed only once pre-blossom, and that, on apples, lime-sulphur at pink-bud was reduced from the usual $2\frac{1}{2}$ per cent. to $1\frac{1}{2}$ per cent. because the trees had received the green-bud application only a few days previously. Two important changes were introduced with the advent of spring spraying, one, the use of three instead of two nozzles on each lance and a consequent reduction in the spraying team from six men for four, and two, the use of lead arsenate powder instead of paste when surplus stocks of the latter had been used. The former change was designed to improve efficiency of cover without slowing down the work, and the latter to speed up the mixing. Both changes proved satisfactory, not least on account of their popularity with the men, who appreciated the extra output, width and range of spray, for it lightened arm-work, while the already popular trigger releases prevented waste of spray-fluid when the men moved from tree to tree. There is evidently a maximum limit to the increase in output of wash that each man, spraying from the ground and pulling his hose, can economically handle. This varies with different spraying conditions, notably the agility of the men, the size and distance apart of the trees, and, very important, the state of the ground. It seems that, for our conditions in general, the maximum limit is in sight now that each man has three nozzles each fitted with discs of $\frac{4}{64}$in. orifice and is spraying at approximately 400 lb. pressure per square inch. Any further necessary developments, given the existing 10 h.p. outfit, would appear to lie in slight modification of disc-orifice size or of delivery pressure.

The spraying was well up to time pre-blossom, but the blossom period was prolonged by unfavourable weather. As the early apple blossoms had been frozen, it was considered unwise to apply the petal-fall spray while there was a chance of the later blossoms setting fruit. The period that elapsed between applications of spray at pink-bud and at petal-fall was therefore at least a month, and during that period primary Scab-infection occurred. From reports received, it seems that growers over a wide area were faced at petal-fall with the same perplexing choice either of checking Scab and possibly sterilizing the late blossoms, or of risking Scab infection while giving the late blossoms every chance to set fruit. Most of them thought, apparently, that some fruit, even though scabbed, is better than no fruit, and they chose the latter course. The result, with us and with them, was that Scab-control was not really satisfactory after a very promising beginning, and it further illustrates that weak post-blossom sprays can only be really effective if applied before Scab has become well established.

Pears were sprayed but little post-blossom because the frost had cracked the skin of the fruitlets, which would thus have been the more susceptible to spray damage.

Cotton-seed oil proved useful where Bordeaux mixture was applied. It definitely reduces foliage injury, improves disease control and, incidentally, has the distinct advantage of appreciably lubricating the pumps.

The Research Station reference number of each of the plots sprayed is given among the details below to facilitate comparison of the sprays applied to any one series of plants throughout the season.

The symbols used for the sprays are :—

B.M.	Bordeaux mixture.
L.S.	Lime-sulphur.
A.	Lead arsenate (paste or powder indicated).
N.	Nicotine.

All sprays are referred to in quantity of concentrate used in 100 *gallons.*

Routine Spraying Programme, 1938.

Period.	Spray used.	Hosts.	Sprayed against.	Remarks.
30th Dec., 1937—4th Feb., 1938.	**Tar-oil emulsion** containing: 3 gals. strained anthracene oil, ½ gal. oleine, 1 lb. caustic soda.	Apples, Pears, Plums, Cherries, Black and Red Currants and Gooseberries.	**Aphis.**	All plots excepting 12 (Worcester), 32 (Cox and Worcester), part of Kiln Field (Worcester), and any plantations with strawberries as undercrop (Deadman plums and Plot 35 young apples). Also Plot 29 (plums and sweet cherries) used for spraying experiments.
5th Jan.	**Tar-oil emulsion** containing: 6 gals. strained anthracene oil, 1 gal. oleine, 1½ lb. caustic soda.	Morello Cherries	**Aphis** and **Brown Rot** (*Sclerotinia laxa*).	Plots 29, 35.
9th and 24th Feb.	**Petroleum-oil emulsion** containing: 5 gals. petroleum oil. 1 quart oleine. 6 oz. caustic soda.	Plums and Pears.	**Red Spider** (*Oligonychus ulmi*).	Plot 21, where plums alone are planted, and Plots 20 and 36, pears alone.
21st. Feb.-18th March.	**Petroleum-oil emulsion** as above, but with 6 gals. oil.	Pears and Red Currants, Plums and Black Currants, Apples.	**Capsid** (*Plesiocoris rugicollis* and *Lygus pabulinus*) and **Red Spider.**	Plots C2, C3, C4, 2-5, 8, 10-18, 27, 30-34, N1, N2, K1 and 2. Where pears and plums were interplanted with the soft fruit, they had the 6% spray for convenience.
21st March.	**N.** (8 oz.) + 0·25% **Soap** (1 quart oleine, 6 oz. caustic soda).	Plums.	**Aphis.**	Deadman, where tar-oil could not be used because of strawberries.
22nd-24th March.	**L.S.** (2 gals.).	Black Currants (*just pre-blossom*).	**Big-Bud Mite** (*Eriophyes ribis*).	Plots N2, C4.
22nd-24th March.	**L.S.** (2½ gals.) + **A.** (4 lb. paste).	Pears (*white-bud*).	**Scab** and **Caterpillar.**	Plots 8 (cordons), 20, 27, 36.
28th March.	**L.S.** (2½ gals.) + **A.** (4 lb. paste).	Apples (*green-bud*) and Pears (*white-bud*).	**Scab** and **Caterpillar.**	Plot C3 (apples and pears interplanted).

ROUTINE SPRAYING PROGRAMME, 1938 (*continued*).

Period.	Spray used.	Hosts.	Sprayed against.	Remarks.
29th March.	**L.S.** (1 gal.) + **A.** (4 lb. paste).	Apples (*green-bud*).	**Scab** and **Caterpillar.**	Plot C2 (a manurial plot, in part subject to spray-damage).
29th-31st March.	**L.S.** (2½ gals.) + **A.** (4 lb. paste).	Apples (*green-bud*).	**Scab** and **Caterpillar.**	Plots 3, 4, 10, 11, 30, 31, 33-35, K1. Young apples on Plot 35 had **N.** (6 oz.) in addition for they had had no tar oil.
31st March-2nd April.	**L.S.** (2½ gals.) + **A.** (2 lb. powder).	Apples (*green-bud*).	**Scab** and **Caterpillar.**	Plots 2, 5, 8 (cordons), Upper Grub, 12-14, 16, K2.
4th April.	**L.S.** (2½ gals.) + **N.** (8 oz.).	Apples (*pink-bud*).	**Scab, Caterpillar, Aphis** and **Sucker** (*Psyllia mali*).	Bradbourne.
5th-8th April.	**L.S.** (1½ gals.).	Apples (*pink-bud*).	**Scab.**	Same plots as at green-bud. C2 again had 1%.
13th April.	**N.** (8 oz.) + 0·25% **Soap.**	Loganberries and Blackberries.	**Aphis** (*Macrosiphum rubiellum*).	Plot C5a.
19th and 20th April.	**Flowers of Sulphur.**	Established Strawberries.	**Powdery Mildew** (*Sphaerotheca Humuli*).	Plots 3, 22, 28, N3.
20th April and 6th May.	**B.M.** (4 lb. bluestone, 6 lb. hyd. lime) + **cotton-seed oil** (3 quarts).	Pears (*petal-fall* and *post-petal-fall*).	**Scab.**	Plots 20 and 36 (omitting Conference). The spraying was started, then continued later, as frost intervened and cracked the skin of the young fruitlets.
9th-13th May.	**L.S.** (1 gal.) + **N.** (8 oz.).	Apples (*petal-fall*).	**Scab** and **Sawfly** (*Hoplocampa testudinea*). Useful also against **Red Spider** and **Apple Capsid.**	Plots C2, C3, 3, 4, 5, 10, 12-14, 16, 18, 30, 31, 33, 35, K1 and 2. All Lane's, Duchess Favourite, Lord Derby, Belle de Boskoop. Chas. Ross, Gladstone, Edward VII, Beauty of Bath, Grenadier, Rival and Early Victoria omitted. Plot 8 (cordons) with **L.S.** (3 quarts) + **N.** (8 oz.).

Routine Spraying Programme, 1938 (*continued*).

Period.	Spray used.	Hosts.	Sprayed against.	Remarks.
13th-19th May.	**N.** (8 oz.) + 0·25% **Soap.**	Apples (*petal-fall*).	**Sawfly.** Also **Apple Capsid.**	All varieties excepted above, Plots C2, C3, 3, 4, 10, 11, 16, 30, 33, 35, K1.
25th May-1st June.	**L.S.** (3 quarts).	Apples (*second post-blossom*).	**Scab, Mildew** (*Podosphaera leucotricha*) and **Red Spider.**	Plots C2, C3, 3, 4, 8 (cordons), 10, 12, 13, 14, 16, 30, 31, 33, 35, K1 and 2, omitting same varieties as omitted with **L.S.** at petal-fall.
3rd June.	**N.** (5 oz.) + 0·25% **Soap.**	Established Strawberries.	**Aphis** (*Capitophorus fragariae*).	Plots 22, 28, N3.
3rd June.	**Flowers of Sulphur.**	Established Strawberries.	**Powdery Mildew.**	Plots 3, 22, 28, N3.
15th June.	**N.** (5 oz.) + 0·25% **Soap.**	Black Currants.	**Aphis.**	Plot C4.
15th June.	**N.** (5 oz.) + 0·25% **Soap.**	Pears.	**Aphis.**	Plot C3.
13th-16th June.	**N.** (5 oz.) + 0·25% **Soap.**	Hops.	**Aphis** (*Phorodon humuli*).	Plots C5, 26, 27, Upper Grub.
16th June.	**N.** (5 oz.) + **Soft Soap** (5 lb.).	Plums and Sweet Cherries.	**Aphis** (*Phorodon humuli* and *Anuraphis padi*).	Plot 29 (used in dormant season for spraying experiments).
16th June.	**N.** (5 oz.) + **Soft Soap** (5 lb.).	Apples.	**Aphis.**	Plot 35 (young trees).
18th June.	**N.** (5 oz.) + 0·25% **Soap.**	Hops.	**Aphis.**	Plots C5, 26, 27, Upper Grub.
18th June.	**N.** (5 oz.) + 0·25% **Soap.**	Blackberries	**Aphis.**	Plot C5a.
20th June.	**Derris** (2 lb.) + **Soft Soap** (5 lb.).	Raspberries.	**Raspberry Beetle** (*Byturus tomentosus*).	Plots 28, 29, N1.
21st June.	**Flowers of Sulphur.**	Strawberries (runner beds).	**Powdery Mildew.**	Plots N3, Deadman, Upper Grub, Merryweather.
22nd and 23rd June.	**L.S.** (3 quarts) + **N.** (5 oz.).	Apples (*third post-blossom*).	**Scab, Mildew, Red Spider** and **Aphis.**	Plots C2, C3, 3, 4, 10, 12, 16, omitting varieties as with **L.S.** at petal-fall.
23rd-30th June.	**L.S.** (3 quarts).	Apples (*third post-blossom*).	**Scab, Mildew** and **Red Spider.**	Plots 13, 14, 30, 31, 33-35, K1 and 2, omitting varieties as with **L.S.** at petal-fall.

ROUTINE SPRAYING PROGRAMME, 1938 (*continued*).

Period.	Spray used.	Hosts.	Sprayed against.	Remarks.
30th June-8th July.	**A.** (2 lb. powder).	Apples.	**Codling** (*Cydia pomonella*).	Plots C2, C3 (apples only), 3, 4, 10-14, 16, 31, 33-35, K1 and 2. All trees that carried appreciable crop.
12th and 13th July.	**B.M.** (10 lb. bluestone, 15 lb. hyd. lime) + **N.** (5 oz.).	Hops (*pre-burr*).	**Downy Mildew** (*Pseudoperonospora Humuli*) and **Aphis.**	Plots C5, 26.
14th July.	**B.M.** (5 lb. bluestone, 7½ lb. hyd. lime) + **cotton-seed oil** (3 quarts) + **N.** (5 oz.).	Hops (*pre-burr*).	**Downy Mildew** and **Aphis.**	Plots 27 and Upper Grub.
8th August.	**B.M.** (5 lb. bluestone, 7½ lb. hyd. lime) + **cotton-seed oil** (3 quarts) + **N.** (5 oz.).	Hops (*post-burr*).	**Downy Mildew** and **Aphis.**	Plots C5, 26, 27, in part.
9th August.	**B.M.** (10-15-100) + **N.** (5 oz.)	Hops (*post-burr*).	**Downy Mildew** and **Aphis.**	Plots C5, 26, 27, to complete.
18th-20th August.	**L.S.** (1 gal.).	Strawberries (runner beds).	**Powdery Mildew.**	Plots 22, 30, 34, Deadman, Upper Grub, Merryweather.
9th September.	**Flowers of Sulphur.**	Strawberries (runner beds).	**Powdery Mildew.**	Plots Deadman, Merryweather.
20th October.	**B.M.** (10-15-100).	Sweet Cherries.	**Bacterial Canker** (*Pseudomonas mors-prunorum*).	Plot C4.
16th November.	**B.M.** (10-15-100).	Sweet Cherries.	**Bacterial Canker.**	Plot C4.

(M.H.M.)

Section II

GENERAL REVIEW OF RESEARCH WORK

WITH SUMMARIES OF PAPERS PUBLISHED DURING THE YEAR

I. POMOLOGY

In Relation to Tree Fruits.

ROOTSTOCK INVESTIGATIONS.

As indicated in the Farm Report, the cropping of all trees on the Station was seriously affected by the warm March and consequent early season followed by severe frosts and cold winds at the height of blossom time. To this the main rootstocks trials were no exception and variable crops of apples, pears and plums were harvested. The resistance or susceptibility of different varieties was very marked, some yielding on the whole good crops. This may have been connected with the stage of development of the blossoms or a definite resistance to low temperature injury. In other varieties, the beneficial effect of efficient pollination was strongly suggested, only the trees very near to another variety carrying any crop at all.

The effect upon tree to tree variability in future years seems likely to be accentuated. (R.G.H. and J.A.)

1. Apple Rootstocks.

Of the four principal varieties under trial, Worcester Pearmain (Plot 12) and Lane's Prince Albert (Plot 11) bore fair crops. In the former, however, rootstock effect upon tree size led to a marked differential response to the weather conditions of the year, since all trees bore little fruit below a six foot level above ground. Trees on such stocks as No. IX and No. IV bore practically nothing, while the taller trees carried fair crops upon the higher branches.

The alternate trees of Bramley's Seedling (Plot 13) on all but the most dwarfing rootstocks, as forecast last year, have now to be removed to allow the rest room for development. This plantation formerly consisted of Bramley's Seedling and Worcester Pearmain alternate at 15 feet square. The Worcester Pearmain have already been removed, leaving a quincunx plant of Bramley's 30 feet square with one in the centre. Even when this centre tree has been removed, Bramley's Seedling on all rootstocks except Nos. VIII, IX and VII will still be too close—a fact considered incredible at the time of planting.

At the same time the importance, now the Worcester Pearmain trees have been removed, of efficient pollination for Bramley's Seedling, is being borne in mind and one tree in five will be frameworked to Grenadier.

In the case of Lane's Prince Albert also, trees on the vigorous rootstocks are, at 15 feet apart, much too close and it is planned gradually to remove alternate trees also, the most vigorous, e.g. Nos. XII and XVI, being taken out first.

The Cox's Orange Pippin trees (Plot 32) have shown clearly in recent years the difficulties and disadvantages of continuing indefinitely a uniform pruning treatment for trees on all rootstocks, which has been the practice in the past on all such trials. It has therefore been decided to prune the vigorous trees on Nos. II, XVI and XIII, less drastically than the remainder, which now show the need of harder pruning in order to maintain vigour.

It has been reported that under conditions at the Station, Cox's Orange Pippin has been dwarfed on No. I rootstock and proved very vigorous on No. II.

It is planned to obtain further information about the relative performance of different varieties upon these two rootstocks and under different conditions of soil and climate, and subsequently to design an exact experiment thereon.

Records are to be continued on the Lord Derby, Allington Pippin and Grenadier half-standard trees on a series of vigorous stocks. In view of the outstanding performance of these half-standard trees upon the layered Crab rootstocks Malling A and C, an attempt will now be made to propagate them more readily since they respond indifferently to layering, a fact which has hitherto prevented their recommendation to commerce.

Detailed records have been taken for the 12th year on the Lane's Prince Albert trees on the complete series of Long Ashton layered free stocks. It is now impossible to continue these upon all combinations, but observations will be maintained upon those of outstanding interest, e.g. G8 (vigorous), F11 and G7 (dwarfing), also A10 and D1 (partially incompatible with Lane's).

The trees required for the large scale planting of Cox and Worcester upon Nos. I, II, IV, VII, IX and XVI, which are to be used for a study of the economic aspect of rootstock effect, were budded during the past season and will be ready for planting out in the autumn of 1939. (R.G.H. and J.A.)

Records are being continued on the fifteen-year-old trees of Grenadier on Northern Spy and Crab H inarched with No. XII in February, 1934. The effect of the inarching, which was originally shown by those particular branches which were in direct vascular connection with the rootstocks is becoming more general and the trees made good growth in 1938.

The forty-two stunted trees of Heusgen's Golden Reinette on No. IX inarched with Nos. IV, IX and XII in the spring of 1936 made more wood growth last season than for some years past, but this did not appear to be influenced by the inarched rootstocks. (A.B.B., R.G.H. and W.A.R.)

Cordon Trials. Considerable differences now exist in the vigour and cropping of the five-year-old Cox and Worcester single cordons on Nos. I, II, IV, VII, IX and XII, planted at 1 ft. 9 ins. and 3 ft. 6 ins. apart in the rows. Judged on thickness of stem, the trees of Cox on No. IX are smaller than those on No. II, and these are smaller than the trees on Nos. I, IV or VII, while those on No. XII are the largest. The trees at 3 ft. 6ins. apart in the rows are considerably larger than those at 1 ft. 9 ins.

Trees of Cox on Nos. IX and II have borne larger crops than those on Nos. I, IV or VII, and those on No. XII have borne the smallest crop. There is very little difference between the crop per tree of the close and wide spaced trees. The Worcester trees have shown similar differences in growth but have borne a smaller crop than the Cox trees. The mean crop per tree for Cox on No. IX is approximately 5 lb. and

for Worcester on No. IX 1 lb. from 1935 to 1938 inclusive. The very low figures are due to the entire loss of crop through frost in 1935 and 1938. (A.B.B.)

Dwarf Pyramids. Detailed records of growth and cropping are being made on a small trial of three-year-old Cox and Allington trees on Nos. I and XVI, trained as dwarf pyramids. The trees of Cox on No. XVI are already 30 per cent. larger than those on No. I, while the trees on No. I have borne 50 per cent. more fruit buds than those on No. XVI. (A.B.B.)

Mechanism of Rootstock Effect. The stem- and root-worked trees of Lane's Prince Albert on No. II, IX, XII and seedling stocks, planted as two-year-olds in January 1932 have reached maturity at a comparatively early age. Owing to the fact that the trees have been left unpruned to bring them into cropping as soon as possible, even those on the more vigorous rootstocks bore a considerable crop in 1937, and blossomed freely in 1938, although the crop was not very high owing to the severe spring frosts. The trees were worked on stock stems and piece roots to study the source of rootstock influence and to discover whether it resides partly or wholly in the stock stem, as distinct from the stock roots in these rootstocks.

The trees which were root-worked on Nos. IX, II and XII, and in which all stock stem was eliminated, still manifest all the signs of rootstock influence shown in their early years. The unions of these trees have been kept below ground so that no part of the root is exposed to light and air. Precautions have been taken to prevent scion-rooting.

The recent data collected on cropping confirm the earlier records of vigour and fruit bud formation in showing that rootstock influence lies in the root as well as in the stem of vegetatively raised rootstocks.

The trees on No. IX (whether stem- or root-worked) bore the heaviest crop in the early years, but latterly those on No. XII (both stem- and root-worked trees) and certain of the seedling stocks have given even larger crops owing to their greater framework. The number of fruits per metre wood growth, however, is still less on No. XII than on No. IX. The trees on No. II have always been intermediate in crop between Nos. IX and XII.

Detailed microscopic observations have been made on the internal structure of the roots of Nos. VII, VIII, IX and eight new clonal rootstocks raised by crossing Nos. VIII and IX, all worked with Lane's Prince Albert. The variation found in the internal structure of these rootstocks was examined in relation to the vigour which they imparted to the Lane's Prince Albert scions. A close correlation was found to exist between vigour and (1) the bark:wood ratio, (2) the percentage area of wood rays, wood fibres and vessels, (3) the size of the vessels, as seen in transverse section. A report has been written on the correlation between the vigour and structure of these rootstocks. It is hoped from these beginnings to develop a technique for forecasting the probable performance of new rootstocks from an examination of the internal structure of the young plants before they are worked.

In extension of this study the following work has been begun :—

(1) Roots have been preserved from three-year-old trees of Lane's Prince Albert on (i) Northern Spy, Nos. II, IX, XII and four new clonal rootstocks raised from Northern Spy, (ii) Nos. IV, VI, IX and a series of new clonal rootstocks obtained by crossing these three stocks. A study of the internal structure of the roots will be made in relation to the vigour and cropping of the trees from which they were taken.

(2) Further observations have been made on the internal structure of stems and roots of four-year-old unworked plants of the rootstocks Nos. I to XVI. The structure is being examined in relation to the vigour which these rootstocks are known to impart to scion varieties.

(3) Unworked plants of eight rootstocks which are used commercially in some districts although not widely distributed, have been planted. They will be lifted at about two year old and sections of the stems and roots made. The internal structure will be compared with that of Nos. IX, II, XII and XVI planted at the same time.

Roots have been preserved from thirty one-year-old seedlings grown from the open pollinated seeds of a mature tree of No. XII. The internal structure of these seedling roots will be compared with that of one-year-old adventitious roots from layered plants of No. XII clone this season, and in 1940 a similar comparison will be made between the structure of two-year-old roots from seedlings and layers. This work should indicate whether there are any structural differences to account for the more ready influence of the scion upon the rootstock when grafted direct on to one-year-old seedling roots than when grafted on to either the same aged clonal or older seedling roots, as found by some workers. (A.B.B., E.C.T., R.G.H. and J.A.)

2. Pear Rootstocks.

In spite of the early promise of a full pear crop, only those varieties in the rootstock trials bore any appreciable quantity of fruit, and even these suffered from severe skin damage and were almost entirely seedless. Conference, once again, bore the most fruit and there were light crops of Beurré Hardy and Doyenne du Comice.

Observations are being continued upon those three varieties, now 19 years old, and a fourth, one year younger, Durondeau, upon Quinces A, B and C, to ascertain the differential effect of those three quince stocks for the period of their profitable life.

A new collection of quince rootstocks is being assembled. This includes varieties from European, Caucasian and South American sources. After botanical descriptions have been made, all will be subjected to propagation tests and an investigation made of their compatibility with pear varieties known to be difficult to work on quince.

The best of the quince seedlings from the Caucasus, already tested, will be included in this series.

Attempts are being made to find a commercial method of propagating clonal pear rootstocks of proved value. The rooting of hardwood, softwood and root cuttings with and without the assistance of growth controlling substances is being explored. (See Physiology, p. 69.) (R.G.H. and J.A.)

Unworked plants of clonal pear rootstocks C2, C4, C7 and C8 and quince rootstocks, A, B, C and D, have been planted for a study of the internal structure of their stems and roots. They will be lifted at two years old and their structure examined in relation to the vigour which they are known to impart to scion varieties.

(A.B.B., E.C.T., R.G.H. and J.A.)

3. Plum Rootstocks.

Only three varieties included in the plum rootstock trials bore appreciable crops in 1938. These were Czar, President and Cluster Damson. Fair crops of the first were harvested, while President bore only slightly less than in 1937, trees on Myrobolan B and Pershore averaging 80 and 96 pounds per tree respectively. Cluster Damson, particularly on Myrobolan B, also bore well, these averaging 100 pounds per tree.

A proportion of the trees of Czar, Purple Egg, and Utility, originally in the rootstocks trials, were frameworked with a comprehensive collection of high quality dessert plums and gages, with two objects in view, viz. the further exploration of methods of frameworking plum trees and the selection of one or more good commercial dessert plums. (See 9, p. 43.) (R.G.H. and J.A.)

4. Peach and Apricot Rootstocks.

No suitable opportunity has yet arisen for the lifting and final recording of the fourteen-year-old trees of Hale's Early on a range of rootstocks planted against a board fence. The trees again failed to crop. The acquisition of Bradbourne, with its extensive walled garden, has raised the hope that it will be possible to carry out peach rootstock trials and obtain regular crops of fruit for recording purposes. A beginning has been made by collecting suitable scion varieties and rootstocks and these have been set aside for budding in 1939.

A questionnaire was sent out during the autumn to horticultural officers in counties where apricots were known to be commonly grown and the replies have enabled us to plan preliminary trials of this fruit upon a range of rootstocks. The more satisfactory trees resulting from this trial will be used in trials in the walled garden at Bradbourne where apricots are known to crop satisfactorily. (R.J.G.)

5. Cherry Rootstocks.

The transfer of the layer beds of recently obtained cherry rootstocks to fresh soil has given much improved results ; all varieties are very much more vigorous, and several of the Mazzard selections have already rooted more satisfactorily than in recent years. The rooting of the acid cherry stocks is still generally poor, but is likely to improve with the age of the layer bed.

The earlier selections of the silver barked Harz Mazzard having been only moderately successful under vegetative propagation, a further set has been obtained from Germany ; these will first be tested for ease of propagation. Claims are made on the Continent that these stocks, which are raised from the seed of wild trees, produce very healthy long-lived trees of the scion varieties worked on them. (R.J.G. and N.H.G.)

Sweet Cherry Scions. Owing to the frosts in April and May, no fruit was picked from any of the stock trial trees. Early Rivers and Turkey Heart have still remained relatively free from bacterial canker, whilst Bigarreau de Schrecken, which has suffered severely in the past, seem rather less affected than in recent years. The spraying trials for the control of bacterial canker on the latter variety have now been concluded. (N.H.G.)

Acid Cherry Scions. For the third time in four years the trees cropped very lightly ; there was a moderate crop on the higher ground at the west end of the older Morello plot, but little fruit on any of the three varieties elsewhere.

The Morello trees kindly planted for us by Mr. D. J. Moor at Teynham bore their first partial crop. The fruit was very irregularly distributed, and did not seem to show either rootstock or positional influences at all clearly.

Ornamental Flowering Cherries. Buds of 12 species and varieties of flowering cherries have been obtained during the year ; of these six or more are believed to be new to the collection. (R.J.G. and N.H.G.)

PROPAGATION.

6. Preparation of Experimental Material.

The collection and testing of new rootstocks for ease of vegetative propagation has been continued. The stool shoots of two hundred and fifty-eight selections of Woolly Aphis immune apple rootstocks were retained on the parent stools at the end of 1937 and grafted in March, 1938, with scions of Lane's Prince Albert in order to obtain some indication of the compatibility of these rootstocks, with this variety. (See 30a, p. 48.)

In collaboration with the Physiology Sections (see 65a, p. 69) investigations in connection with the technique of vegetative propagation and studies of the effect of growth controlling substances upon the rooting of hardwood and softwood cuttings and layers have been extended and intensified. Six new electrically heated frames were installed in the existing propagation house towards the end of 1938 and these will be in full use in 1939. A field trial involving some five thousand hardwood cuttings of the plum rootstock Myrobolan B, from four sources and prepared in two ways has been planted. Half the cuttings will be irrigated during the coming summer, according to the dryness of the soil.

The study of the causes of variability in nursery material, in collaboration with the Statistical Section (see II. 63, p. 65), has involved the budding of over three thousand rootstocks in different ways. (R.J.G.)

7. Nursery Technique Trials.

A batch of sixteen hundred No. IX Jaune de Metz rootstocks in the nursery was used for repeating the trials of covering newly inverted buds with petroleum jelly. Trials in previous years have suggested a possible superiority of treated buds but it appears to be necessary to repeat the test over a period of years before arriving at a definite conclusion. (R.J.G.)

8. Compatibility and Incompatibility between Stock and Scion.

The first nursery of the new series planned to continue the study of the effect of climate upon compatibility and variability of nursery material has been planted on Newgates Field and successfully budded.

Twenty-three varieties of choice dessert plums budded upon six different plum rootstocks in 1937 were carefully measured at frequent intervals throughout the growing season in order to obtain information concerning the growth rates of these varieties. Once again Oullin's Golden Gage has proved incompatible with Myrobolan B, and Comte d'Althan's Gage, not previously worked upon Myrobolan B at East Malling, has behaved similarly. No other incompatibilities have yet appeared.

(R.J.G. and R.J.H.)

The anatomy and histology of the bud unions of Conference, Dr. Jules Guyot and Marie Louise pears on seedling quince stocks was studied from some 300 microtome sections. Classifications were made on the basis of the degree of compatibility found, and these were correlated with strength-at-union figures obtained with a breaking apparatus. See 32a. (R.J.H.)

9. Top-Working and Frameworking Methods for Mature Trees.

Largely owing to the adverse weather conditions at blossoming time and partly to the heavy crop in 1937, the trees of Laxton's Superb, frame- and top-worked upon

Newton Wonder in 1935, bore little fruit in 1938. The publication of the results of this trial has been postponed until the trees have borne a second full crop when it should be possible to determine the relative merits of the grafting systems employed.

Further frameworking trials carried out in 1938 have involved the grafting of Cox's Orange Pippin upon the varieties Gladstone and Bramley's Seedling, and of Worcester Pearmain upon Gladstone.

Four methods of frameworking, with Worcester Pearmain as the scion variety, namely stub-grafting, side-grafting, inverted L bark-grafting and awl-grafting, using four- and eight-bud scions, inserted at monthly intervals from February to June inclusive, have been tested on forty-four twenty-two-year-old trees of Gladstone. Similar trees have also been frameworked with "many" and "few" scions in order to compare the effect of these variations upon growth and cropping of the new scions. Other similar trees have been subjected to different treatments of the sucker shoots from the original scion variety. In one case the suckers were removed as they arose and in the other they were left until the end of the growing season.

Ten pear trees of the varieties Marie Louise and Reine des Poires were frameworked with the varieties Laxton's Superb, Dr. Jules Guyot, Beurré Bosc, Doyenne du Comice and Williams's Bon Chrétien in order to test the possibilities of frameworking desirable varieties on two which have proved unsatisfactory. All the trees have made good growth during their first season. Some seventy plum trees have been frameworked in different ways. (See 3, p. 41.) The cleft-grafts, such as the stub- and side-grafts, have been more successful than the rind-grafts, represented by the inverted L bark-graft and the awl-graft. As it has been suggested that the variety Czar does not respond to re-working with dormant scions, a few trees of this variety were framework budded in July to test this method. The strong gales experienced in June and early July, when the new scions had made vigorous growth, blew out many of the scions. It may be necessary to modify the technique in future in order to overcome this trouble. Summer pinching of the shoots and possibly the use of more scions per tree may help.

Ten graft-sealing compounds were tested upon frameworked apple trees during 1938, most of the substances proving quite satisfactory. These will be tested on a large scale in 1939. (R.J.G. and R.J.H.)

ROOT DEVELOPMENT.

10. Root Growth Investigations.

A further year's observations on the root growth of mature apple trees on stocks Nos. I, IX and XVI have been obtained at monthly intervals. The data for four years have now been summarized and written up. A historical survey of root investigations, and a report on the trials of effect of light on growing roots carried out by means of small observation boxes have also been written. All three papers will be published shortly.

Measurements of thickening of roots behind the glass observation windows, by means of a microscope with graduated eyepiece, commenced in 1937, have proved difficult to continue, for as thickening proceeds and the centre of the root is forced farther from the glass the edges tend to become obscured. (W.S.R.)

11. Soil Moisture Meters.

Twenty-one soil moisture meters have been used in various trials, and have given interesting information on the water usage by various crops in a dry summer. The water-conserving effect of bare fallow has once more been clearly shown. In a

strawberry irrigation trial, water was applied when the soil moisture tension, as shown by the meters, reached 45 cm. Hg, in the soil areas occupied by most roots. This irrigation gave a large increase in crop (see p. 94). (W.S.R.)

12. Root Excavations.

The data obtained from the excavation of Early Victoria apple trees with 5½ ft. intermediate stem pieces of various " stem-builder " varieties have been written up, and are in the press. (W.S.R., A.B.B. and C.P.P.)

Three eight-year-old trees of Miller's Seedling, one of which was top-worked with Cox in May, 1938, another frameworked and the third not re-worked, were excavated in detail. It was found that the main root system appeared similar on all three trees, no sign of dying back in the roots of the top-worked or frameworked trees being apparent. An attempt is now being made to record the fibrous root produced during the year, to determine whether this shows any difference. (R.J.H. and W.S.R.)

The root systems of several mature hop plants were excavated. (See p. 53.) (F.H.B.)

SPECIAL ASPECTS.

13. Investigations in Biennial Bearing.

The trees of Early Victoria in the " Pruning Plot ", which are being used for a renewed trial of " on " and " off " year spur-shortening, bore a moderate crop of fruit in 1938 (their " on " year) in spite of the frosts. There is little so far to show whether pruning in the " off " year has reduced biennial intensity more than pruning in the " on " year, as was expected. Since the " on " year crop of 1938 was considerably reduced by frost, the result may not now be according to expectation ; it would not be surprising if all the trees showed a much reduced biennial intensity. (N.H.G.)

An intensive study of biennial bearing, initiated in 1935, is being continued in collaboration with the Physiology (III 64h) and Insecticides and Fungicides (VII 96) Sections (see sections III and IV). (R.G.H. and M.C.V.)

14. Double Working of Fruit Trees.

Apples. Nursery Trial of " Stem-Builder " Varieties as Intermediates. A report was completed during 1938, and will be published early in 1939. (R.J.G. and N.H.G.)

Other Apples. The four rows of oldest trees, planted at the end of 1919, were thinned early in 1938 by the removal of diagonal trees wherever overcrowding was becoming serious. Although the trees of Worcester Pearmain carried a fair crop, there was little to suggest that the removal of some trees affected the size or colour of the fruit borne by the trees next to the gaps so caused. Other varieties bore at most only a very light crop, and in some cases none at all. (N.H.G.)

Pears. Nursery Trial. This was concluded early in 1938, with a record of the weight of the head of each tree. The dwarfing effect of the Orange Bergamotte intermediates, referred to in last year's Annual Report, was shown even more clearly by weight of head than by measurements ; and where both quince and pear rootstocks were used (the second scion varieties being Comice and Bose), it was relatively greater on pear stock than on quince. Since Orange Bergamotte is itself a vigorous variety, its dwarfing influence as an intermediate, on all the four second scion varieties so far tested, is unlikely to be related to a partial incompatibility with the rootstock, as was

at first thought possible. These results will be written up for publication as opportunity offers. (R.J.G. and N.H.G.)

Other Pears. Following the " off " year in 1937, almost every tree blossomed profusely in 1938, but only Dr. Jules Guyot produced more than a few scattered fruits. The remainder bore practically none, except, in certain cases, a number of partly formed fruits from second blossom. The tendency to produce second blossom does not seem to be clearly influenced by the variety used as intermediate. (N.H.G.)

15. Non-Setting of Pear Blossoms.

The manipulation that was found necessary last year in order to level up the growth of Glou Morceau and Comice in the single U cordon trees grown as a " sap transfusion " experiment has had a partial result of reducing the vigour of the Glou Morceau half of the tree. There was no crop owing to frost. (N.H.G. and N.B.B.)

In continuation of the study of factors influencing the setting of pear blossom, a block of a quarter of an acre of pear plantation was sheltered by hop lewing for comparison with a similar unsheltered block to determine whether the setting of the blossom was affected by the shelter. Wind, temperature and soil moisture records were made. Four thousand individual flowers on eight trees of the varieties Conference and Pitmaston, in sheltered and exposed positions were labelled in an attempt to follow their setting in relation to their position in the truss. Weekly measurements of the diameter of the fruitlets were made, but frost caused nearly all of them to fall within a few weeks and no records on fully developed fruit were obtained. Records of the size and fresh weight of individual flowers of Conference from known positions in the truss were made on another set of trees. Constant differences in size and weight according to position in the truss were found. (R.G.H. and A.B.B.)

A trial of dehorning in relation to blossom setting has been continued. (See 17.) (J.A.)

PRUNING.

16. Apples.

Of the eight varieties remaining in the Apple Pruning Plot, four, Early Victoria, Grenadier, Lord Derby, and Rival, had a definite " on " year in 1938, and produced well over half a crop, in each case considerably more than in 1937. Of the remainder, two, Beauty of Bath and Cox's Orange Pippin, had a very light crop. The other two, Newton Wonder and Worcester Pearmain, which had cropped well in both 1936 and 1937, bore roughly half a crop. In view of the frosts of April and May, this is better than might have been expected.

In spite of the very dry spring, growth was usually vigorous, especially where the formerly unpruned trees have for several years been closely pruned.

The trial of " on " and " off " year spur-shortening on Early Victoria is referred to under 13 above. (N.H.G.)

Cordons. The effect of summer and winter pruning treatments on the vigour of single oblique cordons (Cox and Worcester), planted in the spring of 1935, is now clearly visible ; but no difference in cropping is apparent yet. The crops have been very small, however, owing to the severe spring frosts experienced in 1935 and 1938. Half the trees are entirely pruned in summer (July and September), and half receive their main pruning treatment in winter, the lateral shoots being simply shortened to about 7-8 inches in August.

The "winter pruned" trees have thicker stems than those pruned entirely in summer, and they also bear larger darker green leaves. The length of the leading shoot is greater in the summer pruned trees, however. The earlier and more drastic pruning of the laterals in the summer pruned series appears to result in the leading shoot obtaining better conditions for growth in length. The leading shoot itself is not pruned in either series of trees. (A.B.B.)

Dwarf pyramids. No great differences in growth and cropping have been observed so far between the three-year-old trees of Cox and Allington receiving differential pruning treatments. (A.B.B. and N.B.B.

17. Pears.

The experiment on the effect of three different methods of pruning on the growth and cropping of nine varieties of pear, grown as cordons, is being continued. No marked difference in growth have yet appeared and any differences there might have been in cropping were eliminated by the spring frosts. (N.B.B.)

Data from the sixteen-year-old pear trees under different pruning treatments show that with certain varieties, e.g. Conference, Durondeau and Hessle, the greatest total weight of fruit has been produced where the trees have not been leader tipped and have had only light thinning of the branches. This is in part due to the good natural framework which these varieties have made under this treatment.

In two other varieties, i.e. Emile d'Heyst and Beurré Amanlis, similar treatment has resulted in badly shaped trees, and those which have been regularly leader tipped and the laterals "spurred" have given the larger amount of fruit. With all varieties, the leader tipped and spurred trees have in most years given slightly larger fruits.

In the trial of younger trees, now in their eleventh year, the trees under all treatments produced abundant blossoms but any differential effect of pruning upon set that might have occurred was entirely wiped out by frost.

In a further series the trees have been dehorned. One set of trees of Pitmaston Duchess were treated just prior to blossoming and another when the blossom was fully open. With Conference one batch of eighteen-year-old trees was dehorned in their "off" year, and another will be similarly treated in the "on" year, 1939. (See 15.)
(J.A.)

18. Plums.

The double-worked stem-builder trial of Victoria, one set of which has been pruned in September and another in May, with the object of comparing the spread of Bacterial Canker under these two treatments, have made good growth. Some deaths from canker have occurred. (See Pathology p. 76.) (J.A. and H.W.)

19. Cherries.

Owing to the very light and uneven crop of Morello, it was not possible to obtain any further data on the effect of dehorning on cropping. (N.H.G.)

THINNING.

20. Apples.

Some trees of Lane's Prince Albert on Nos. I, II, IX and XVI have had their fruit thinned as considered necessary from 1934 onwards while others have been left unthinned. A comparison is being made of the results. (A.C.P.)

21. Plums.

Trials are being continued as opportunity offers. The progress report on the thinning of Victoria plums referred to last year will be found on page 139. (A.C.P.)

MANURING.

22. Apples.

The experiments now in progress consist of (a) a complete comparison of nitrogen, potash and phosphorus, alone and in all combinations, (b) a comparison of the effects of 4 and 8 cwt. of sulphate of potash on trees which had hitherto had no potash and (c) a preliminary experiment in which nitrogen is given at various times, (d) a trial of humus.

The storage experiment in collaboration with Dr. West of the Ditton Laboratory, using fruit from the first of these experiments, could not be carried out this year as the crop was variable owing to frost injury to the blossom.

The trouble thought to be possibly due to magnesium deficiency was further investigated.

In connection with the question of humus and the nutrition of the tree a preliminary test of various cover crops has been begun, including mixtures recommended by the Welsh Plant Breeding Station, Aberystwyth, the object being to see which are the most suitable for our conditions.

23. Pears.

The preliminary field experiment with pears has been continued. There was an indication of an effect of potash on the foliage and a slight indication with nitrogen.

24. Plums.

Trees of eight varieties of Damson on Myrobolan B are being grown on for a preliminary experiment on the effect of various quantities of nitrogen on biennial bearing and delayed fruit ripening. (W.A.B.)

IRRIGATION.

25. Effect of Artificial Irrigation.

A strawberry irrigation trial gave very successful results, and artificial watering was also used on a small area of runner beds. (See 57, p. 94.) (W.S.R.)

Preparations have been made for differential water applications to a series of young apple trees in pots. The effect on growth and on incidence of disease will be noted, in collaboration with the Insecticides and Fungicides Section (see VII 97a, p. 88). (W.S.R. and M.H.M.)

VARIETIES AND CLASSIFICATION.

26 and 27. Apples and Pears.

A number of the varieties of apples grown on plots 31 and 33 have been added to the cordon varieties. (H.C.C.)

28. Cherries.

Scions of two varieties, believed to be new to the collection, were received during 1938.

There was too little fruit on the established trees to allow of description or the identification of doubtful varieties. Notes on habit of growth and susceptibility to Bacterial Canker have been continued. (N.H.G.)

SPRAYING AND TREE PERFORMANCE.

29. Observations in Collaboration with Insecticides and Fungicides Section.

The relation between tree condition (as influenced by cultivation and manuring) and susceptibility to functional disorders, to diseases caused by parasitic organisms, and to infestation by insect pests, is being given close attention, particularly on the apple manurial plot, but also on trees in sand cultures with different nutrients.

(W.A.B., M.H.M., R.M.G., H.W. and W.A.R.)

FRUIT BREEDING.

30. Apple Rootstocks.

(a) *Varieties Immune from Woolly Aphis.*

The raising of new varieties of apple rootstocks immune from attack by Woolly Aphis has been continued in collaboration with the John Innes Horticultural Institution. Since there are now some eight hundred seedlings of proved immunity undergoing propagation tests, no further families have been raised. The trees grafted on two hundred and fifty-eight selections propagated as described in Section 6 have been removed from the stools during the present winter and planted out as a nursery trial. There is no evidence, so far, of any serious incompatibilities between these rootstocks and Lane's Prince Albert, but the trees are already showing striking differences in vigour.

The four seedlings, Merton 778, 779, 789 and 793 have now been growing in a nursery trial, budded with Lane's Prince Albert, for four years, for comparison with Northern Spy and Malling Nos. II, IX and XII. Up to the present, trees on these four immune rootstocks are more vigorous than those on Spy, IX or II, but slightly less vigorous than trees on XII. There were large differences in vigour between them, trees on 778 being the least vigorous and those on 789 the most vigorous. In blossom production, trees on all four immunes have been less prolific than trees on No. IX or II but, with the exception of those on 778, they have so far been more prolific than those on Northern Spy. All of them were far more prolific than trees on No. XII.

(b) *Crosses between "Paradise" Varieties.*

Anumber of new varieties of rootstock raised by crossing certain of the "Paradise" among themselves with the primary object of gaining information on their inheritance and influence on the scion, have been under observation. Most of the characters studied showed great variation and the mode of inheritance is apparently very complex. About thirty new varieties selected from crosses between No. IX and a wide range of other "Paradise" rootstocks have been propagated in quantity and worked with Lane's Prince Albert. Large differences are already appearing in their relative vigour and precocity. The nursery trials, six and nine years old, containing nineteen selections from a family No. VIII × No. IX, worked with Lane's Prince Albert continue to exhibit very large differences in vigour and blossom production. It is hoped, in due course, to select from among these improved semi-dwarfing and semi-vigorous types.

A further nursery trial of trees of Lane's Prince Albert, planted in 1934, worked on 180 different clonal rootstocks, the progeny of two families No. IV × No. IX and No. IX × No. VI has been grubbed during the present winter. There were again wide

differences in vigour, many of the trees being more dwarfing than No. IX and many more vigorous than No. VI. A complete set of these trees has been excavated and their root systems examined. There were very large differences in the character of the root systems and in the relative amount of fibre. A paper dealing with this work is in course of preparation.

A programme of collaborative work has been arranged to test the efficiency of the method of predicting the influence of the rootstock on the vigour of the scion from a study of the anatomy of the roots. (See 1, p. 39.) (H.M.T.)

31A. Plum Rootstocks.

The attempt to find new varieties of plum rootstocks more readily propagated by vegetative means and giving a greater range of influence over the scion than existing varieties, is being continued. Families from crosses between the most commonly used varieties are now being studied and several other families are ready to plant out for trial. So far, only a few of the seedlings which have been subjected to propagation tests have given promise of being ready rooting in their earlier years, but the trials will be continued. It is hoped to extend this work by inter-crossing a number of other plum varieties as material becomes available.

31B. Pear Rootstocks.

Several batches of pear seedlings, raised from open pollinated seed of the East Malling Clonal Free Pear rootstocks have been raised and their botanical characters closely studied. A paper dealing with this material will be found on page 110. A programme of controlled breeding among these Free Pear rootstocks will be carried out during 1939 to ascertain how far the various "types" breed true.

32A. Testing of Imported Wildings.

The wilding apple and pear seedlings from the Caucasus have been growing for several years, both as stools, to test their capacity to root readily by this method, and as trees growing on their own roots and on No. IX and Quince C to obtain observations on the quality of their fruits. Neither growth nor rooting has been satisfactory on the stools. The trees growing on their own roots are now seven years old and quite vigorous but they have not yet fruited. A description of the chief leaf and shoot characters of the pear seedlings appears elsewhere in this report. In general, they have been found to vary comparatively little among themselves. These seedlings will be retained until it has been possible to test the quality of their fruits.

The collection of quinces, obtained from the same source, have been used for a compatibility test with the three pear varieties, Conference, Dr. Jules Guyot and Marie Louise. This work has been published (E136). In most cases the trees have been left growing on the stools for a further year and have shown wide differences in the amount of wood growth and fruit bud which they have made. Certain of the trees remaining on the stools are being used for an intensive study of the morphology of their unions. The stools will be prepared later for a further trial with incompatible varieties. (H.M.T.)

32B. Germination of Pomaceous Seeds.

Extensive experiments have been carried out during the past two seasons, in collaboration with the Department of Agriculture and Forestry, Pretoria, South Africa,

on the best methods of germinating pear seeds. A short progress report is published on page 103. (H.M.T.)

33. Scion Varieties of Apples.

Several further families have been raised with the object of obtaining scion varieties of apples of commercial value immune from attack by Woolly Aphis. A number of seedlings of proved immunity, worked on No. IX, for fruiting, have now been planted out. In spite of the frost, some fruit was obtained from many of the seedlings, raised in 1929, in an endeavour to produce apples of the Worcester Pearmain type with an extended season of ripening. Several seedlings from a cross between Worcester Pearmain and McIntosh Red have shown promise and scions from three of them were frameworked on to older trees in the winter of 1937-8. A batch of seedlings raised from crosses between several of the best dessert varieties will be worked on to rootstocks during the coming season. Crosses will be made between late blossoming varieties of apples with the object of producing seedlings of commercial value sufficiently late flowering to escape destruction by spring frosts.

Genetical studies on the inheritance of fruit colour and shape in apples are being continued. Crosses designed to shed light on the nature of the factors involved have been made and fruits have already been obtained from some of the seedlings.

(H.M.T.)

34. Scion Varieties of Pears.

The programme of breeding work designed to produce new pear varieties of high quality and commercial promise is being continued, and several large families of pear seedlings, raised from crosses between varieties of good quality, will be worked on to quince. A number of families raised previously are already undergoing trial on quince but none of them has fruited so far. (H.M.T.)

35A. The Shortening of the Juvenile Period.

Since the results obtained in previous years have shown conclusively that the use of a dwarfing rootstock is the most effective method of bringing seedling apples into early fruiting under our conditions, no further attempts to find fresh ways of shortening the " juvenile " period are being carried out at present. (H.M.T.)

35B. Studies on Pollen Influence.

Studies on the influence of different pollens on the growth and development of the fruits in both apples and pears have been continued. A progress report has been published (E137). Experiments during the past season again showed that, although the varieties of apples and pears used would set fruits with the pollens of several other varieties, fruits were set and matured more plentifully with certain sorts of pollen than with others. Each individual flower on the trusses of some apple and pear trees was pollinated with a different pollen. In every case a larger number of fruits were matured with certain pollens than with others and on some trees no fruits at all were matured with a given pollen when placed in competition with other pollens, although fruits were set when that pollen was used alone. Where a number of pollens were tried in pairs, two being applied to each truss, there were indications of a similar prepotence of one pollen over another in many cases. Experiments on the effect of the time of pollination were also carried out. Arrangements have been made to continue this work. (H.M.T.)

MARKET QUALITIES.

36. Marketings.

Investigations are being continued with regard to the different methods for the marketing of fruits with special reference to the influence of such factors as variety, stock, season, thinning, manuring, and cultural operations, and their effect on market value. (A.C.P.)

SOIL TYPES AND PLANT PERFORMANCE.

37. Fruit Soils Survey.

The six plots on farms on various soil types were maintained and observed. (W.A.B. and W.S.R.)

Special Investigations.

WALNUTS.

38. Field Observations on Frost Damage, and Testing of Varieties.

High temperatures in March caused the buds of many varieties to move into growth as early as the end of the month. Eleven degrees of frost on 11th April destroyed all prospect of their producing a crop of nuts. The late leafing out varieties, being dormant at the time, were little affected, and growth on them was more normal until 7th May when 11 degrees of frost killed some of the young growth and many of the most forward flowers. Even so, some trees bore a fair crop from the less exposed flowers especially on trees in which pollen was present and ripe at the same time that the stigmas were receptive. One tree (in flower about 25th May) in which this condition obtained bore 300 large nuts of *maxima* type. The period of pollen ripening and stigma receptivity ranged from 24th May to 12th June. Observations will be continued on this important point as well as upon the date of leafing-out.

Although approximately 20 per cent. of the nuts had rather soft shells due to seasonal conditions, yet the kernels in such nuts were well developed, of good flavour, and excellent for immediate consumption. It would appear that even in such unfavourable seasons as 1938 a moderate commercial crop may be expected on mature trees of late leafing varieties.

Variety Collection of Grafted Trees. It is planned to raise a duplicate set of all varieties for extended trials, all of the same age, to be grafted on one-year seedlings of *Juglans nigra.*

Propagation of a limited number of trees for distribution to Members is being continued.

Budding in the Open Ground. The experience of former years that only good mature buds of the previous season's growth are successful has been confirmed. Unfortunately a sufficiently good method of budding in the open air in this country to replace grafting under glass has not yet been discovered.

Transplanting 17-year-old Trees. Two grafted trees planted in 1925 when 3-4 years old, were carefully lifted, without any previous preparation, in November, 1937, and replanted on a site about a mile distant. Both these trees recovered and made short new growth in 1938. (A.W.W.)

HOPS

39A. Testing of New Varieties.

During the past season 31 new selections from Wye have been planted out in place of those grubbed. The crop from about 240 seedling varieties was dried separately in order that the yield per acre could be estimated. Samples of the dried crop from over 90 varieties were collected in air-tight glass jars for subsequent resin analysis. The crop from about 50 varieties was pressed separately in part pockets to provide material for physical examination by an expert or for brewing trials.

The analysis of the 1937 crop showed that the early variety OR76 was easily the richest in its class, with an analysis of 12·7 per cent. This variety is only a light cropper, but as it makes little bine growth it might respond to close planting. In the mid-season class, HH44 was again first with an analysis of 15·12 per cent. This figure is the third highest for the season. The yield of this variety is not high enough (about 15 cwt. per acre) to allow of its recommendation for commercial cultivation at present. The next richest mid-season variety, BB28, had an analysis of 13·41 per cent. and may have a commercial future if brewing tests are favourable.

Among the late varieties " Bullion Hop " (Q43) came first with a P.V. of 16·50 per cent. closely followed by " Brewer's Gold " (C9a) with 16·02 per cent. The richest commercial variety was " Early Bird " with an analysis of 11·31 per cent., seven of the new varieties exceeded this figure. Five new varieties beat the richest American growths (Sonomas 12·85 per cent.).

The work has been carried out in collaboration with Professor E. S. Salmon who has published a report, and Mr. A. H. Burgess of the South-Eastern Agricultural College, who has been responsible for the analyses.

39B. Cultural Trials.

With Brewer's Favourite close planting again gave an increase in crop. In order to reduce the quantity of matted bine and consequent difficulty in controlling Downy Mildew should the season prove wet, only one bine was trained up each string on the closely planted hills in 1938. The cropping results obtained, therefore, once again confirm the fact that the number of bines per string has only a slight influence on the yield.

The lightly pulled hills had considerably more forward bine when measured at the end of May, but there was no difference in cropping due to the pulling treatments. In the Fuggle trial one strain again gave a heavier crop.

Stopping the bines of seedling OV7 at the lacing string reduced the crop per acre by about 2-3 cwt., where two or three bines were trained up each string. Where only one bine was trained up the crop was reduced by about 5 cwt.

After " stopping " the first two laterals were trained up in place of the main bine. The season was rather unfavourable for this trial as severe winds occurred at the time when the stopped bines were making new growth, and some of the leading laterals were damaged so that they actually had a double check.

The combined time of cutting and pulling treatments on Quality Hop (OO63) were started this season. The bine on the early cut plots was affected by the May frosts. The leaves appeared silvered and failed to grow to normal size, and the bine was brittle. The bine was some time in growing away from this check. The growth on all plots was measured at the end of May and large differences in average length of bine in the several treatments were recorded. There were, however, no significant variations in cropping.

As the seedling P13 has failed to respond to either close planting or light pulling, this trial will be ended.

The plot of the New Mexican seedling O147 is now fully established and manurial treatments will be started in 1939.

The object of this trial is to ascertain if a very vigorous variety can be grown with a low nitrogenous manuring, and also if it can make full use of very wide spacing.

39c. Commercial Varieties.

Many observations have been made on the collection of clonal Goldings, with a view to enabling these varieties to be recognized in the field. These observations must be continued and comparisons made with the varieties in commercial gardens before any definite conclusions can be drawn. So far it appears that the differences between the several true Goldings are only slight, and may possibly be differences of season only.

Pure clonal races of the chief Goldings are being propagated for use in various trials.

39d. Root Studies.

The root systems of some six-to-eight-year-old hop hills of three varieties have been excavated by the "skeleton" method and the results are being prepared for publication. (F.H.B.)

For Diseases and Pests of Hops see

V. Plant Pathology, Mycology and Bacteriology, 80a, and

VI. Entomology, 81, 86c and 86d.

HORTICULTURAL METEOROLOGY.

40. Phenological and Meteorological Records.

(a) *Routine Meteorological Records.*

Observations under the Agricultural Meteorological Scheme of the Ministry of Agriculture have been continued.

Monthly summaries of the weather conditions have been contributed to the Kent Farmers' Union Journal and a summary of the year's records is published elsewhere in the report. (See p. 145.) (H.C.C. and H.M.T.)

The instrument designed here, which records the lifting and sinking of the soil surface due to frost and other causes has been in operation through the year, and has given interesting results. (W.S.R. and H.C.C.)

(b) *Low Temperature Injury to Fruit Blossom.*

Following the severe frosts which were experienced in April and May, 1938, some preliminary investigations were made on low temperature injury to apple blossom of two late flowering varieties, Crab A and Court Pendu Plat, cut from the trees and exposed to varying degrees of freezing in constant temperature chambers. Blackberry blossoms were used for some of the later experiments when apple flowers were not available. The work was carried out at the Ditton Laboratory by kind permission of the Superintendent, Dr. C. West, and in consultation with Mr. J. K. Hardy. A progress report appears on p. 127. (C.P.F.)

(c) *Micro-climatology.*

A programme has been drawn up, and the work will be taken up in relation to (d) below, when facilities are available. (T.N.H. and R.G.H.)

(d) *The Study of Katabatic Winds and Air Temperatures in Relation to Frost Damaged Orchards.*

The severe frosts in the spring of 1938 provided good opportunities for this work. A survey of the frost damage caused in orchards in this district was made, and observations were taken on the microclimate of this district during the blossoming season.

The survey showed that, on the whole, orchards in valleys were more damaged than orchards on hilltops, but there were a few orchards on hilltops that were damaged and a few orchards in valleys that escaped. One of the orchards on a hilltop escaped frost damage in 1935, but did not escape in 1938, although conditions in and around it were apparently similar in both years; another orchard half way down a valley side escaped damage in both 1935 and 1938, although the orchard next to it suffered heavily in both these years.

Records were made of the temperature differences (a) between the air in similar orchards on the hill and on the valley side, and (b) between the air in cultivated and grassed orchards on the valley side. Records were also obtained of low velocity air movements on the hill and on the valley side.

Regarding (a) it was found that the amount of wind and cloud is important. On nights when the sky was clear and very calm, even on the hill, a large temperature difference was found between hill and valley, the valley being the colder, and strong katabatic winds were found on the valley side. On nights when it was "calm" in the ordinary sense, but there was a little more air movement, or cloud, or both, a relatively small temperature difference between hill and valley, and feeble katabatic winds on the valley side, were found. On nights when it was a little more windy or cloudy, or both, the valley was found to be warmer than the hilltop, as it usually is on a sunny day, and there was no katabatic wind on the valley side.

Regarding (b) it was found that the effect of the spring vegetation on air temperature was not so great as that of summer vegetation, and that it was usually most marked on the clearest calmest nights, although on some such nights it was small.

In addition to the above observations in spring at East Malling, observations were made on the influence of altitude and vegetation on air temperature in the winter of 1937-8 near Canterbury and in the summer of 1938 at Long Ashton, Somerset. These give support to the conclusions given above, as well as to those obtained in previous years. (C.E.C.)

In Relation to Small Fruits.

CLASSIFICATION, NOMENCLATURE AND VARIETIES.

41A. Black Currants.

Goliath bore the heaviest crop of about 21 cwt. per acre, this being largely attributed to the fact that at the time of the frosts the flowers of this variety were mostly in the bud stage and the racemes still compact. Seabrooks yielded about 17 cwt. per acre, but the early flowering varieties, such as Boskoop, Baldwin and Triple X, were all severely damaged by frost. (J.A.)

41B. Red Currants.

In the variety trial all red currants gave their heaviest crop to date. The small fruited varieties such as Houghton Castle, Fertility and La Constante again gave the heaviest yields. Of the larger fruited varieties Versailles and Chenonceau also gave good crops and, as in previous years, the fruit of these fetched a higher price per pound. (J.A.)

42. Raspberries.

See under IX.

43. Loganberries, Blackberries and Dewberries

See under XI.

44. Strawberries.

See under X.

BREEDING.

45. Black Currants.

The work carried out during the past twenty years at this Station on the raising of improved varieties of black currants has now been summarized and published (Esf. 37).

An extended trial of seedlings from crosses between the chief commercial sorts, selected as promising new varieties, yielded its first crop of fruit during the past season. A number of other seedlings are now being propagated for trial. Further crosses between the principal varieties and the best existing seedlings are being carried out. Several large batches of seedlings raised from selfing black currants which were themselves bred from ovules, pollen and seeds treated with X-rays, at the John Innes Horticultural Institution, are now ready to be planted out in order to see whether mutations were caused among the recessive genes of the parents. Bushes of a hybrid between the black currant and a Chinese species, *Ribes longeracemosum*, are, at present, undergoing treatment in an attempt to induce polyploidy, at the John Innes Horticultural Institution. (H.M.T.)

46. Red Currants.

Breeding work among red currant varieties has been in abeyance during several seasons. Arrangements are being made to resume this work, during the coming spring, by intercrossing a number of red currant varieties and related species. (H.M.T.)

47. Raspberries.

See under IX.

48. Strawberries.

See under X.

PROPAGATION.

49. Currants.

A clonal disease-free nucleus is being maintained.

50. Raspberries.
See under IX.

51. Gooseberries.
Clonal dessert varieties are being maintained.

52. Strawberries.
See under X.

53. Loganberries and Blackberries.
See under XI.

PLANTING, TRAINING, PRUNING, THINNING.

54. Currants.
The distance of planting trials have been maintained. (J.A.)

55. Raspberries.
See under IX.

56. Gooseberries.
Fruit thinning trials are being continued as opportunity permits. (A.C.P.)

57. Strawberries.
See under X.

58. Loganberries and Blackberries.
See under XI.

MANURING.

59. Raspberries.
See under IX.

60. Strawberries.
See under X.

PUBLICATIONS DURING 1938.

(With Summaries of Papers which did not appear in the Annual Report for 1937.)

In Relation to Tree Fruits.

Studies in the non-setting of pears. Part I. Fruit drop and the effect of cultural practices.
D. N. Srivastava. Journ. Pom. and Hort. Sci. 1938, **16**, 39-62. (E133.)

Experiments were carried out during two years to find the causes of dropping of pear flowers and fruits and to see whether dehorning, ringing or branch bending

would throw any light on this problem. One free-cropping variety (Conference) and two shy-cropping varieties (Doyenne du Comice and Pitmaston Duchess) were employed, and the results were as follows :—

1. There are two waves of dropping, (i) a very early shedding of non-fertilized flowers, (ii) a late, and by comparison, light, dropping of partially developed fruits, popularly known as the June Drop.

2. The main cause of June Drop did not appear to be lack of fertilization, since plenty of apparently healthy seeds were found in most of the fruits dropped.

3. The size of the individual fruit was found in both years to be correlated with its length of life on the tree. The smaller the fruits, the shorter their life ; or, the larger the fruits, the longer they remained attached, thus indicating that the dropping of fruits was due to competition for nutriment.

4. Drastic dehorning, i.e. cutting the main branches back to eight-year-old wood, definitely increased the set of fruit in the year of treatment; unfortunately its effect in the following year could not be followed, owing to abnormal weather conditions preventing any fruit setting.

5. Ringing gave no consistent improvement in the set of fruit, but definitely induced increased fruit-bud formation.

6. Bending over and tying down the main branches of both young and established trees gave rather variable results, both as regards the set of fruit and the formation of fruit-buds.

Studies in the non-setting of pears. Part II. The effect of weather conditions. D. N. Srivastava. East Malling Res. Sta. Ann. Rep. for 1937, (May, 1938), 128-44. (E134.)

Studies in the non-setting of pears. Part III. The effect of the flower characters. D. N. Srivastava. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 145-53. (E135.)

The wild Fruit Trees of the Caucasus and Turkestan. Their Potentialities as Rootstocks for Apples and Pears. I. A First Report on some wild Quinces from the Caucasus. H. M. Tydeman. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 103-16. (E136.)

The Influence of Different Pollens on the Growth and Development of the Fruit in Apples and Pears. H. M. Tydeman. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 117-27. (E137.)

Studies in Incompatibility of Stock and Scion. II. The Relation between time of Budding and Stock-scion Compatibility. R. J. Garner and D. H. Hammond. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 154-7. (E138.)

The Kent Cherry Orchards : Their Management and Crops. N. B. Bagenal. Journ. Min. Agric., 1938, **45**, 323-30. (E142.)

An account of cherry growing in Kent with descriptive notes on the soil, varieties, management and crops.

The Frameworking of Fruit Trees. R. J. Garner and W. F. Walker. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 242-56, and Imp. Bur. Hort. and Plantation Crops. Occasional Paper No. 5, April, 1938. (Eg13.)

Framework Grafting of Fruit Trees. W. F. Walker. Journ. Roy. Hort. Soc. 1938, **63**, 9, 429-39. (Eg15.)

The development of frameworking technique from 1920 to 1931, in order to check the ravages of disease, is described and frameworking as practised today is shown to be practicable upon a commercial scale.

The " Inverted-L Bark Graft ", " V-shaped Bark Graft ", " Chisel Graft ", " Awl Graft " and " Stub-Graft " are described in detail.

The importance of the right selection and storage of scion wood and the use of a sufficiency of long scions is strongly advocated.

A programme of " after-care " is given, together with suggestions as to suitable methods of pruning.

Winter Pruning of Apple Trees. Some Advice based on East Malling Experiments. N. H. Grubb. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 237-41. (Ep9.)

Hybridisation. H. M. Tydeman. Guild Gardener. Jan., 1938, **13**, 1, 6-7. (E129.)

This paper gives a brief outline of the technique of the plant breeding and the elementary principles of the science of genetics as they are likely to interest the practical horticulturist. Modern theories of plant selection and the pure line are described, and the bearing of the evolution of plants in nature and their spontaneous mutation on modern breeding theory is discussed. The Mendelian principles of inheritance and the ways in which they can be utilized by the plant breeder in search of new and improved varieties of plants are outlined and discussed.

Fruit Tree Roots and Soil Conditions. W. S. Rogers. Rep. of the Men of the Trees Summer School and Conference, 1938, 11-12. (E157.)

The root growth of mature apple trees on loam, sand, and clay is described and compared. The relation between root and stem growth and various soil factors, as shown by excavations and in root observation trenches, is discussed. Various limiting factors including soil hardness, fertility, aeration and moisture, are noted.

The School Fruit Plot. N. B. Bagenal. Kent Education Gazette, July, 1938, 1-5. (Eg14.)

Some suggestions about form of plot, kind of material to use, and subjects for demonstration in a school fruit plot, with suggested plans for lay-out of school fruit plots and nursery.

(See also Statistics : E139, E141.)

Walnuts.

In Quest of better Walnut trees. J. B. Hamond. Journ. of the Men of Trees (April-May, 1938), **2**, 4, 79-80. (E126.)

English walnuts frequently bear nuts of poor quality. Foreign walnut trees differ chiefly from our own in that they are vegetatively raised, named varieties. An attempt is now being made to improve English walnuts by growing vegetatively propagated trees of good varieties.

Selected varieties were first ascertained to be self-fertile and late in leafing-out, so avoiding our spring frosts. Seven native trees were chosen for extensive propagation, and four foreign varieties. Walnuts are difficult to propagate out-of-doors in this climate, but grafting under glass is successful.

Well-sealed nuts may easily be stored for winter use. Fallen nuts should be immediately harvested, washed, bleached in a solution mainly of chloride of lime, and, when dry, stored in a mixture of coconut fibre and common salt.

Grafted trees are raised not only for nuts but for " burred walnut " timber.

In Search of better Walnuts. J. B. Hamond. Journ. Min. Agric., 1938, **45**, 38-43. (E127.)

The popularity of Walnuts in England and the poor quality of the home-grown crop in comparison with those from abroad is emphasized. The advantages of the foreign method of growing walnut trees vegetatively as opposed to raising them from seed are mentioned.

Reference is made to an attempt, initiated by the late Mr. Howard Spence, of Southport, to improve the quality and quantity of English-grown walnuts by vegetative propagation. The characteristics of a good walnut are tabulated, and brief descriptions of the foreign and native varieties selected for extensive propagation in this country are given. The importance of the selected trees being self-fertile is emphasized, and mention is made of the large demand for vegetatively raised walnut trees in this country.

A Survey of the Investigations on the Propagation and Testing of Walnuts at the East Malling Research Station. A. W. Witt. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 259-65. (E140.)

Walnuts. J. B. Hamond. Nuts, Ministry of Agriculture Bulletin No. 106, 1937, 16-34.

The English walnut is known as *Juglans regia* L. The tree is monoecious, pistillate and staminate flowers being distinct, although borne on the same tree. Other walnut species are described briefly, and the principal uses of walnut timber are mentioned. Walnut trees in England are nearly always grown from seed and frequently bear inferior nuts, in comparison with those grown abroad, which are borne on vegetatively raised trees of named varieties. An attempt to improve English walnuts by raising grafted trees is being made. Seven established English trees and four well-known French varieties have been selected for propagation in this country. At present young trees are raised by grafting under glass, as little success has been obtained out of doors. One-year-old seedling rootstocks of *J. nigra* or *J. regia* have been used for grafting, as walnuts do not root easily from cuttings or layers. Seedling rootstocks will be replaced by layered rootstocks as soon as these are available in sufficient numbers. The preparation of scions and methods of spring and summer grafting, using the double whip-and-tongue graft, are described with illustrations. Out-door budding has given more promising results than grafting and mention is made of a successful technique, still in an experimental stage, in which dormant buds from the previous season's growth are used. Walnuts prefer a deep, fairly heavy loam soil containing plenty of lime. Good drainage is essential. The pistillate flowers are very susceptible to freezing, so that low sites should be avoided. Walnuts should be planted at least 40 ft. apart, and the ground kept cultivated until they are established. Methods of pruning recommended to produce a standard walnut or a small bush tree are discussed. In considering walnut storage problems emphasis is laid on the importance of harvesting the nuts as soon as they fall and on effective cleaning of the shells. Nuts should also be bleached to improve their appearance and to make them more resistant to fungi. The temperature and the humidity of the atmosphere are factors to be considered before deciding where walnuts may be stored. If clean, bleached nuts are placed in a mixture of salt and coconut fibre they may be stored successfully under private cellar conditions. Bacterial Blight

is the most important disease of walnuts. Bacteria attack all young growing parts of a tree, often causing nutlets to fall when very small. Control measures include spraying and cutting out diseased wood in which bacteria pass the winter. Two fungus diseases which attack walnut grafts and established trees respectively are described briefly. Mention is made of four pests found on walnuts, none of which is important.

Hops.

A Review of Hop Investigations at East Malling. F. H. Beard. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 161-5. (B30.)

Prices obtained for certain New Varieties of Hops, 1931-1937. F. H. Beard. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 166-7. (B31.)

Twenty-first Report on the Trial of New Varieties of Hops, 1937. E. S. Salmon. August, 1937. (B32.)

1. Of the 233 varieties (new and commercial) tested, five new varieties cropped at the rate of over 30 cwt. to the acre, seventeen at over 25 cwt. to the acre, and fifty-seven at over 20 cwt. to the acre.

2. The number of bushels (Imperial) of green hops required to the cwt. of dried hops varied from 91 to 171.

3. Seven of the new varieties proved on analysis to be richer in preservative qualities than the richest old variety (Early Bird).

4. Five new varieties were richer in preservative qualities than the richest sample of American hops obtainable—the highest two, Q43 (" Bullion Hop ") and C9a (" Brewer's Gold "), by no less than 3·65 per cent. and 3·17 per cent. respectively.

5. Notes are given on recent brewing trials with C9a (" Brewer's Gold ") and OP21 (" Brewer's Favourite "), and HH44.

6. It is pointed out that certain of the new varieties have been shown by brewing tests to be equal, or superior, to imported American hops, both as regards flavour and preservative qualities. An additional hop acreage in this country of these varieties, of some 3,000 acres, would produce a crop capable of replacing the imported American hops, the average annual value of which is about £336,000.

7. The incidence of Mosaic Disease and Downy Mildew is described.

Horticultural Meteorology.

Weather Conditions during 1937. C. H. Chapelow and H. M. Tydeman. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 158-60. (H31.)

Katabatic Winds and the Prevention of Frost Damage. C. E. Cornford. Quarterly Journ. Roy. Met. Soc., 1938, **64**, 553-85. (H33.)

A new instrument for recording air movements of low velocity and air temperature fluctuations, and a portable anti-radiation screen, suitable for a grass minimum thermometer, are described.

Experiments are described showing that certain conditions must be fulfilled in making a just comparison between the air temperature in an orchard-heated plantation and in an unheated plantation.

Observations of air currents on hillsides, on radiation nights are presented, which show that two winds exist, the " hilltop " wind and the katabatic wind. The effect of each on the other in certain localities is described. It is shown that the hilltop wind is able, on the higher part of a slope facing it, to push uphill the air in the first 10 ft. or

so above the ground, and at a lower level to neutralize the force of the katabatic wind, producing a calm belt on the slope.

Experiments designed to demonstrate the magnitude of air temperature differences caused by differences in the vegetative cover of the soil alone, by differences in altitude alone, and by a third unknown factor, are described.

Evidence is presented showing that when a katabatic wind moves down a slope its temperature does not necessarily decrease.

It is indicated how the new information may be applied to the problem of preventing frost damage to crops.

Some Meteorological Factors Affecting the Distribution of Frost Damage to Fruit Trees. I. C. E. Cornford. Journ. Pom. and Hort. Sci., 1939, **16**, 291-319. (H34.)

On nights when the air is not too humid, when the sky is clear and it is calm in the valleys, a light breeze of relatively warm air, called in this paper the hilltop wind, has been found on hilltops. The breeze is able to influence the direction taken by a katabatic wind. The hilltop wind is even able, on the higher part of slopes facing it, to push the air uphill, and at a lower level to counterbalance or neutralize the force of the katabatic wind and thus produce a calm belt on the slope, called here the neutral zone. When the hilltop wind blows on a sloping field in a direction at right angles to the contour lines the katabatic wind moves underneath the hilltop wind in the opposite direction but when the hilltop wind blows obliquely on a sloping field the katabatic wind is deflected by it and the air in the neutral zone moves along the contours. The effect of these two winds on each other in certain other places is described.

The possibility of utilizing the hilltop wind for the avoidance of frost damage on relatively high land is suggested. A knowledge of the conditions affecting the direction of katabatic winds makes it possible to say where the air is likely to be sufficiently calm for orchard heating to be effective.

The differences in air temperature at a height of 3 feet above the ground, caused by differences in soil cover, that occur on some radiation nights in orchards and other fields, have been investigated. The lowest minimum temperatures occur over grassland. The air above bare soil, and that in woods with a complete leafy canopy, is relatively warm, often 6° above that over grassland at a height of three feet above the ground.

Since vegetation influences air temperature it was necessary to eliminate this variable factor when studying the influence of altitude on air temperature. In this way it was shown that in undulating country the air temperature varies with altitude on most radiation nights, the highest places being the warmest. On some radiation nights, however, the reverse was found, showing that other factors, at present unknown, may influence air temperature.

It has been demonstrated that when a katabatic wind moves down a valley or a slope its temperature does not necessarily decrease, but is largely determined by the vegetation over which it passes.

It is suggested that in certain orchards containing long grass exposed to the sky in the blossoming period the danger of frost damage may be reduced by reducing the amount of grass exposed.

Experiments in micro-climatology and with orchard heaters showed that certain conditions must be fulfilled in making a just comparison between the air temperature in a heated plantation and that in an unheated one.

It should be emphasized that the investigation reported here is far from being complete. Until a great deal more becomes known no precise recommendations for the prevention of frost damage can be made.

In Relation to Small Fruits.

Strawberry Cultivation Studies. I. The Performance of Individual Plants of Clonal Families. W. S. Rogers and J. L. Edgar. Journ. Pom. and Hort. Sci., 1938, **16**, 63-90. (Esf35.)

1. Individual plant records of about 2,500 Royal Sovereign strawberry plants of selected clonal races were made, starting from the time of their formation as runners on the parent plant and continuing to the end of their commercial life.

2. Great variation in weight of runner at time of planting was found, viz. from about 40 gm. for the earliest-formed to less than 1 gm. for the latest-formed runners.

3. All healthy runners, whether large or small, early or late, and of whatever position on the stolon, were found to possess the potentiality of becoming equally vigorous and fruitful plants, once they had become established. In the first season after planting out, the plants from the largest runners were the most vigorous and had the greatest cropping potentiality, as shown by blossom records ; but those from the smaller runners caught them up by the second season. In the second and later seasons there were no important differences in vigour and cropping, between plants from runners of different sizes at planting, time of formation, or position on the stolon.

4. There is no need to limit the number of runners per parent in order to get satisfactory results.

5. The smallest runners showed the highest mortality following planting. Under favourable conditions very small runners can be successfully established, but for commercial purposes runners weighing less than 3 or 4 gm. (i.e. about eight washed runners to the ounce) are not recommended.

6. The factor limiting the commercial life of the plants was the incidence of the Yellow-edge disease. The plants did well so long as they remained healthy, but rapidly deteriorated when they became infected.

7. The earlier-formed and larger runners showed a higher proportion of Yellow-edge infection than the others. Possible causes and implications are discussed.

8. The most important basis of runner selection, under the conditions of the trials, was freedom from virus disease.

Strawberry Growing To-day. W. S. Rogers. Cherry and Soft Fruit Show Catalogue, 1938, 11-18. (Esf36.)

Practical notes concerning strawberry growing, based on experiments at East Malling Research Station, are given. Special reference is made to clonal races, selection of runners, cultural factors, virus diseases, Strawberry Aphis, Tarsonemid Mite, runner raising and the management of fruiting beds.

Some Results of Experiments in Breeding Black Currants. Part II.—First Crosses between the Main Varieties. H. M. Tydeman. Journ. Pom. and Hort. Sci., 1938, **16**, 224-50. (Esf37.)

An account is given of observations extending over seven years, on twenty families from crosses between the main varieties of black currants.

The inheritance of the following characters is dealt with: *Leaves:* shape, colour, pose, depth of basal sinus, colour of petioles. *Vigour* and *Season of Coming into Leaf. Flowers :* colour, season of blossoming, length of styles. *Racemes :* length and pose. *Fruits :* size, flavour, texture of skin, season of ripening. *Cropping.*

The characteristics of the ideal black currant variety are discussed and it is shown that while each of the existing commercial varieties has a few desirable characters, no one of them comes near to realizing the ideal completely.

It is thought that the inheritance of certain characters such as season of coming into leaf, shape of the buds and length of the flowering racemes, follow simple Mendelian laws, as was to have been expected, since the black currant is a diploid. Other characters are thought to be much more complex in their mode of inheritance.

The lines along which the work is developing are indicated. It is suggested that larger families from first crosses between certain varieties and crosses between the most promising of the seedlings are likely to give the best results. The possibilities of hybridization between related species of *Ribes* are discussed. Some seedlings from a cross between the black currant and a Chinese species, *Ribes longeracemosum*, are described. These hybrids have been quite sterile during seven years. Attempts to induce mutations in black currant seedlings by treating seeds, ovules and pollen with X-rays have so far proved completely ineffectual.

(See also Statistics: Esf34.)

II. STATISTICS AND RECORDS

61. Records.

As the work of the Station expands and new experiments start to yield results, so the work of the Records Office in filing the field records, the preparation of summaries and statistical analyses of each year's new data, tends to increase. Sampling methods, while they lessen the work in the field, usually entail extra labour in computation, apart from the fact that more individuals are recorded. Advantage has been taken of a comparatively light crop and increased assistance in the Records Office to complete the computation needed to examine the records of shoot growth, and of size and colour of fruit, where sampling methods have largely replaced the measurement of growth or grading of the crop of whole trees.

During the year, in preparation for the revision of the Research Programme, a number of the smaller experiments have been reviewed in order that their future may be decided upon.

The widening scope of the Station's work, even in the Pomology Section alone, has indicated in recent years certain defects and a lack of flexibility in the filing system in use in the Records Office. A more readily adaptable method is now under consideration, and a gradual change over to the new system is contemplated during the coming year. (T.N.H., S.C.P., J.S.P.)

62. Technique of Recording.

In collaboration with the Entomological Section an investigation has been started into the variation in certain morphological characteristics, e.g. length of important parts of two species, of aphides infesting Rubus, *Aphis idaei* Van der Goot and *Macrosiphum rubiellum* Theo. Attention has been especially directed to the nature of the distribution of individual measurements, to the estimation of limits of size for various organs, and to the correlations between these sizes. It is hoped by these enquiries to establish the variation to be expected in known species of aphides, for information of this kind seems likely to be of assistance in deciding whether a supposedly new species is in fact distinct from those already known. (See also Entomology, 81.)

Also in collaboration with the Entomological Section investigations are being made into the variation in populations of *Capitophorus fragariae* Theo., both between different leaves of the same plant and between different plants in a field. This investigation should make possible the critical comparison of infestations of commercial strawberry plantations, and assist in the planning and technique of small scale field trials. (See also under Strawberries, p. 97.) (S.C.P.)

The study of the variation in the keeping quality of McIntosh Red apples, carried out in collaboration with members of the Horticultural Division, Central Experimental Farm, Ottawa, has been completed and a report published. (T.N.H.)

The numerous frameworking trials now in progress have provided new problems in recording technique. In several instances sampling methods have been suggested designed to meet the peculiar difficulties in recording the results of these experiments. (T.N.H.)

63. Experimental Design.

No new major experiments have been designed during the past season at the Station. Several, however, are contemplated and problems in connection with their design are already under consideration in the light of past experience. (T.N.H.)

The study of the variation of 2,500 individual clonal strawberry plants, and its effect upon the plot size, number and shape suitable for various types of trial, has been completed and a report published. (J.L.E.)

In the investigation into the causes of variability still existing in nursery trees upon clonal rootstocks, measurements have been obtained of some 9,000 one-year-old trees in a commercial nursery. Analyses of these records have revealed differences in variability connected with both rootstock and variety. Five years' records on the Demonstration Nursery have been examined and seasonal influences upon "take", maiden height and variability shown. Weekly growth measurements have been recorded during 1938 on sets of budded and grafted trees, including several varieties of apple and pear upon different clonal rootstocks; growth curves have been compared and the changes in variability, as the season progressed, studied. Several experimental sets of trees were budded in August, in which the effects of different methods of budding and types of bud upon the subsequent growth of the trees will be compared. An experiment, also under way, has been designed to study the effect of size and amount of rooting of the rootstock upon the resultant one-year-old tree. (H.B.C.)

The design of nursery experiments, particularly for the purpose of testing the large numbers of new rootstocks or varieties, which are the result of the Station's plant breeding programme, continues to occupy attention. In this connection it is proposed to lay down a trial in collaboration with members of the Pomology Section to try out contrasting methods for such trials. Methods of propagation, spacing, and pruning will be included. (T.N.H.)

PUBLICATIONS DURING THE YEAR.

(With Summaries of Papers not appearing in the last Annual Report.)

Experiments in Sampling Technique. II. Size and Colour of Allington Pippin Apple 1936 Crop. T. N. Hoblyn and J. L. Edgar. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 168-72. (E139.)

A Study of the Variation in keeping quality of Apples in Store : as illustrated by the Behaviour of the Variety McIntosh Red from an Ontario Apple Orchard. T. N. Hoblyn. Supplement to the Journ. Roy. Stat. Soc. 1938, **5**, 129-70. (E141.)

1. An experiment carried out on McIntosh Red apples in Ontario in the season 1936-7, designed to throw light upon causes of variability in the keeping quality of stored fruit, is described.

2. Six samples of 60 apples each were obtained from each of 32 trees in a commercial orchard. The trees were selected to show the effect of differences in position in the orchard and of degree of winter injury.

3. Two of the 6 samples were selected from the trees at random; the other 4 consisted of 12 sub-samples of 5 apples each, taken to represent different categories for size, colour and position of the fruit from each tree.

4. Apples from 16 trees were stored at a temperature of 36° F. in one room and apples from the other 16 in a similar room at a temperature of 32° F. The samples

were so arranged that 1 sample from each of the 16 trees was placed in each of 4 blocks occupying different positions in the rooms.

5. The fruit was removed in June, 1937, and records obtained of core-flush, scald, fungal rotting, shrivelling, etc.

6. The data for core-flush and scald are analysed and the effects of the various factors in the experiment are shown.

7. In room 32° F. there was a considerably greater amount of both core-flush and scald than in room 36° F.

8. Differences between trees in the orchard were very marked both in the random samples and in the graded samples, but the effects of position and of winter injury were not very clear, possibly owing to the limitations of the experimental design and available trees. There was a notable tendency for samples from the same tree to be more like one another than those from different trees, especially in the graded samples.

9. Size, amount of red colouring, and to a lesser extent position on the tree all had an influence on core-flush, but only red colouring was of importance with regard to scald.

10. The variation between samples is shown to depend to a large extent upon the average amount of core-flush or scald present in the samples, those with small amounts being much more variable than those with large. The distribution of the coefficients of variability obtained is compared with those expected for a binomial distribution. While evidently of a similar nature, those obtained were rather higher, the nearer to complete homogeneity within a sample, the closer the approximation to the binomial curve.

11. It is concluded that in designing an experiment to show fine differences, care must be taken to eliminate first the larger differences. Further, it is essential before the main examination is begun to fix carefully the level to which, on the whole, breakdown is to be allowed to proceed.

12. Methods of sampling for use in certain contingencies are discussed in the light of the experience gained in this experiment.

Strawberry Cultivation Studies. II. Variability in plant size and cropping, with special reference to size and shape of plots suitable for use in field experiments. J. L. EDGAR. Journ. Pom. and Hort. Sci. 1938, **16**, 91-100. (Esf34.)

The experience gained over a period of ten years, during which two uniformity trials were carried out, has been used to estimate the variability to be expected in strawberry plants at present. The knowledge gained has been used to determine a suitable plot technique.

The great superiority of clonal material over normal commercial strawberries of a few years ago is amply shown, and the importance of efficient disease control is further emphasized.

With clonal plants, plots of about 1/200th acre (fifty plants—at 3 feet × 1 feet 6 inches), repeated four times, are shown to be sufficient to prove a 10 per cent. difference, but even smaller plots, with slightly higher replication, are shown to be quite practicable, if economy in ground is desired, if guard rows need not be considered, and provided disease is kept under control.

Square plots are always more efficient than long narrow ones.

III. PLANT PHYSIOLOGY

64. Analysis of Growth Relations of Stock and Scion.

(a) *Relative Parts Played by Roots and Stem in Stock Influence.*

A full report has been published on the results of the experiment in which Stirling Castle was double-grafted on to stems and rootstocks on No. XII and IX.

The results of the second experiment, in which the same scion, Stirling Castle, was double-worked on to rootstocks of No. XII, with intermediate pieces of No. II or No. XII stem, appears in this report page 148. It has been found that fruit bud formation tended to become slightly but significantly greater when the intermediate was of the weaker (No. II) stock.

The stock on stock trees, in which the two stocks Nos. IX and XII have been combined as scion, intermediate stem piece and rootstock in all possible ways, were lifted in the winter of 1937-8, weighed and replanted as a field trial. It was noticed that there were large differences in degree of feathering in the scion. It was greatest when the scion was No. IX and intermediate and rootstock both No. XII, and least when the scion was No. XII and the rootstock No. IX. (M.C.V.)

(b) *Time, Nature and Distribution of Summer Growth.*

The analysis of data from previous censuses has been completed, but publication will be postponed until observations have been carried out for a further season. (M.C.V.)

(c) *Seasonal Course of Root and Shoot Growth.*

Further samples of the stock on stock trees have been lifted and analysed morphologically. These trees consist of all possible combinations, as scion and rootstock, of the three stocks Nos. IV, IX and XII. It is proposed to lift the remainder of the trees this winter. (M.C.V.)

(d) *Cambial Activity at the Union.*

This work is in abeyance.

(e) *The Assimilation Rates of Apple Leaves.*

A report appeared in the Annual Report for 1937 (F28). (E.R.L.)

(f) *Seasonal Absorption of Nutrient Salts by Apple Trees grown in Water Culture.*

A series of maiden trees of Cox on rootstocks IX and XII were successfully grown in water culture during 1938. The following were recorded frequently throughout the season ; (i) fresh weight, (ii) diameter of scion at three points, (iii) length of leader growth, (iv) leaf counts and leaf area, (v) the amount of water transpired by each tree. The solutions were changed at about fortnightly intervals and nitrogen and potash analyses of the residual solutions have been completed. The characteristic stock effects were not diminished by the method of culture, the growth of trees on No. XII being very significantly greater than that of those on No. IX. Transpiration rate per unit leaf area was greater for trees on No. XII. On both rootstocks, the total amount

of potassium and nitrogen absorbed was directly proportional to the growth made ; in the early part of the season, however, the trees on No. XII absorbed rather more nitrogen and much more potash than those on No. IX, per unit of fresh weight. The early accumulation was reflected in greater growth of the trees on the vigorous root-stock later in the season. A paper on the results of the experiment to date is being prepared and the trees are being grown in culture for another season. (H.L.P.)

(g) *Water Relations.*

Dr. L. G. G. Warne, of Victoria University, Manchester, has examined the water conducting power of the trunks of the double-worked Stirling Castle on Nos. IX and XII (see (a) above), and has published a report.* He has found "that unions in which M.IX is one component do appear to be less efficient for water conduction than unions in which M.IX is combined with itself, or M.XII is combined either with itself or with a scion".

(h) *Biennial Bearing.*

Dr. Sen, who was primarily responsible for this investigation, returned to India in 1937, but the trees used to test control measures are still under observation to determine the after effects of the treatments. Most of the results have been analysed and prepared for publication. Some of the more important findings may be summarized as follows :—

Relation to tree morphology. The blossoming performance of individual spurs was followed for two successive seasons on trees of four varieties which showed cropping performance ranging from complete regularity to intense biennial rhythm. It appeared that the performance of a spur in the second season was determined less by its own behaviour the previous season than by that of the tree as a whole.

Attempted control measures. These were carried out in 1936 on intensely biennial mature trees of Bramley, some of which were in their "on" and some in their "off" year. Complete deblossoming in the 'on' year changed the year of cropping but did not reduce the intensity of the rhythm. Partial deblossoming and complete defruiting of "on" year trees, reduced the intensity of the rhythm. When alternate branches were completely deblossomed the effect was confined to the treated branches. Partial defoliation of trees in their "off" year, by removal of half the leaves in June, reduced the number of blossoms the following season without reducing the crop either that year or the year of treatment. More severe defoliation was harmful.

Although partial deblossoming in the "on" year, and partial defoliation in the "off" year have given hopeful results, it is too early to say whether effective control is likely to be got by such methods. (P.K.S.)

As deblossoming by hand would not be a practical proposition on an economic scale the use of sprays for this purpose is being examined. See VII Insecticides and Fungicides, 96. Effect of Sprays on Apple Blossom, p. 85.

(j) *Tree Morphology in Relation to Pruning.*

An investigation has been carried out in two consecutive years, on the relative amounts of primary and secondary wood and the relative proportions of each removed in pruning. The main object is to determine how far the efficiency of the method of

* Warne, L. G. G., and Raby, Joan. "The water conductivity of the graft union in apple trees, with special reference to Malling Rootstock No. IX." Journ. Pom. and Hort. Sci., 1939, **16**, 389-99.

using length or weight of prunings as a measure of the wood growth of trees is influenced by differences in the proportions of primary and secondary wood.

(M.C.V. and P.K.S.)

65A. Vegetative Propagation (*in collaboration with Propagation*).

(a) *The Use of Synthetic Root-forming Substances.*

(i) *Softwood Cuttings.* The response of cuttings of several varieties of apple, pear, quince, cherry and plum during 1938 is reported on page 157. The importance of the physiological condition and the source of the cuttings treated for obtaining optimum rooting response after treatment was clearly shown.

(ii) *Hardwood Cuttings.* Cutting of several varieties of plum, pear and cherry rootstocks were treated with indolebutyric acid or with alpha-naphthalene acetic acid before planting in autumn; so far, no improvement in rooting has been obtained.

(iii) *The Analysis of the Factors Governing Rooting Response* in treated softwood and hardwood cuttings and layers is being continued. A constant temperature and humidity room is being set up in the N.F.U. Building to enable the delicate "coleoptile" test to be used to determine the amounts of natural or synthetic root-forming substances present in the plant tissues. (H.L.P. and R.J.G.)

An intensive study of some of the factors governing rooting response was begun in the autumn of 1938. (A.E.P.)

Etiolation.

An intensive study of the effects of etiolation and of the conditions under which this causes better rooting in layers and cuttings, was begun in the autumn of 1938. (A.C.S.)

65B. Phytohormones and the Growth of Apple Trees.

Maiden trees of Cox on rootstocks Nos. IX and XII, planted in the spring of 1938, were sprayed daily throughout the growing season with solutions of alpha-naphthalene acetic acid at concentrations of 1/100,000, 1/1,000,000 and 1/10,000,000. The growth of the leader shoots was greatly reduced by the highest concentration, the trees on No. XII being more sensitive to the treatment than those on No. IX. In the first season there was no significant increase in growth with any treatment. The experiment is being continued for another year. In the coming season attempts will be made to follow the natural hormone production by leader shoots of trees on IX and XII at frequent intervals, to determine if the cycle is different for trees on the two rootstocks. The coleoptile test will be used as indicator.

Experiments are also being carried out to see if it is possible to retard fruit buds by an application of growth substance solutions. Encouraging results have already been obtained, using young black currant plants. (H.L.P.)

65C. The Production of Galls on Apple Rootstocks by Treatment with Growth Substances.

In collaboration with Pathology (see V. Pathology, 70.) experiments on the production of galls on apple rootstocks are being continued.

(H.L.P., R.V.H. and H.B.S.M.)

PUBLICATIONS DURING THE YEAR.

(With Summaries of Papers not appearing in last Annual Report.)

Experiments with Growth Controlling Substances I. The Reaction of Leafless Woody Cuttings to Treatment with Root-forming Substances. H. L. PEARSE. Ann. Bot. 1938, **2**, 227-36. (F26.)

1. Treating the basal ends of dormant willow cuttings with lanolin pastes or water solutions containing indolebutyric acid greatly stimulated the formation of roots at the basal ends of the cuttings.

2. When the apical ends were similarly treated root formation was accelerated throughout the length of the cutting and was not confined to the basal portion.

3. Ringing experiments indicated that indolebutyric acid was transported downward in the region of the stem external to the xylem.

4. After treatment of the apical portion of cuttings the maximum response occurred at the most apical node, the number of roots formed gradually decreasing from the apex to the base.

5. When the portion of the base of the cuttings which had been treated was removed, the effect of the treatment was eliminated.

6. When the treated portion of the base was cut off a further treatment with indolebutyric acid again caused a response.

7. These results suggest that in these experiments indolebutyric acid itself was the active agent concerned in promoting root formation, and was itself used up or chemically changed in the process.

Preliminary Observations on the Carbohydrate Content of Apple Leaves on Different Rootstocks. E. R. LEONARD. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 173-80. (F28.)

The Relative Influence of Rootstock and of an Intermediate piece of Stock Stem in some Double-grafted Apple Trees. M. C. VYVYAN. Journ. Pom. and Hort. Sci. 1938, **16**, 251-73. (F29.)

1. The performance of four series of double-worked apple trees has been followed for six years.

2. The trees were double-grafted at a single operation and consisted of three portions: the scion (Stirling Castle), an intermediate piece of stock stem, and a root system belonging to a piece of stem (rootstock).

3. The stocks used were Malling No. XII (very vigorous) and No. IX (dwarfing), which were combined as root system and intermediate in all four possible ways, A (XII/XII), B (IX/XII), C (XII/IX) and D (IX/IX).

4. The trees on No. XII root systems produced significantly more wood growth and significantly fewer total fruit buds and fruit buds per metre wood than those on No. IX root systems.

5. The trees with No. XII intermediates produced significantly more wood growth and significantly fewer fruit buds per metre wood than those on No. IX intermediates. Differences in total fruit buds were not significant.

6. There was significantly more wood growth and there were fewer total fruit buds where stock and intermediate were of the same variety than when they were different. This significant effect of interaction may have been due to the nature of

the graft unions, though not necessarily so. The difference in fruit bud per metre wood was not significant.

7. Pronounced swellings occurred above graft unions where the lower component was No. IX and the upper Stirling Castle or No.XII. The swellings were morphologically different in these two cases. No swellings occurred above unions between like components or between Stirling Castle and No. XII.

8. The cross section of the intermediate was determined by the rootstock below it, and that of the rootstock by the intermediate above it. As a result the No. IX intermediate in trees of type B became larger than the stems of the No. XII stocks below.

(See also Plant Pathology, C142.)

IV. BIOCHEMISTRY

MUTUAL INFLUENCE OF ROOTSTOCK AND SCION.

66. Elementary Analysis.

(i) Polarographic. No work has been possible.

(ii) Spectrographic. The Ramage method has been modified to make it more sensitive and more accurate. It has been in use for diagnosing certain deficiency diseases, in conjunction with injection methods. Leaf samples, etc., including those submitted by County Advisory Officers and growers have been analysed. A paper describing this work is now ready for publication.

A new method applicable to many more elements than the Ramage method has been evolved in which carbon electrodes are made from the plant material itself without the addition of any foreign material and high tension electric sparks are passed between two of these electrodes in a quartz chamber filled with argon. This method is being standardized for routine use. (W.A.R., F.M. and S.G.T.)

(iii) Chemical. A paper will shortly be published dealing with rapid chemical methods for the analysis of leaf stalks for the preliminary examination of the mineral status of plants. (H.H.)

67. Organic Analysis.

A survey of the organic constituents of fruit trees is being made as a preliminary in determining how far horticultural performance is reflected in organic composition.

The methyl alcohol extracts of leaves and shoots have been separated into fractions by chromatographic methods and fractional distribution between solvents, and a start has been made to identify the various constituents.

Work has also been done on a chemical method of identifying certain rootstocks and varieties by the examination of the coloured lead salts obtained on passing an extract of the material through a column of specially precipitated lead hydroxide. (W.A.R. and J.K.E.)

68. Plant Injection.

A communication covering the general field of plant injection was published during the year. (W.A.R.)

Further experiments have been carried out on plants of various kinds growing in sand culture under known mineral deficiency conditions. (H.H. and B.N.L.)

Results of Injection.

(i) Artificial Manures. Experiments have been carried out on trees receiving known manurial treatment. (B.N.L.)

(ii) Iron Salts for Chlorosis. The work described in the last Annual Report has been put on a semi-commercial scale. (J.B.D. and W.A.R.)

(iii) The effect of nitrogenous and phosphatic compounds. See last year's report. (B.F.G.L. and W.A.R.)

(iv) Nutrients and disinfectants against Silver Leaf. Further observations have been made but final conclusions have not yet been drawn. (W.A.R. and H.W.)

(v) Insecticides against Woolly Aphis. (See VI, Entomology, 82.)

Other injection work is in abeyance pending the return of Dr. Roach from South Africa.

(viii) Effect of nutrient salts on insect pests. An apparent inhibition effect of phosphate on Rosy Apple Aphis has been observed in an injection experiment. (H.H.)

(x) Effect of nutrients on Apple Scab. (See VII, Insecticides and Fungicides, 97.) (B.F.G.L. and M.H.M.)

69. Woolly Aphis.

Isolation of substance causing immunity or susceptibility.

Progress has been made with the chemical side of this problem. (See 67.)

ABSORPTION OF NUTRIENT SALTS BY ROOTS.

See III, Plant Physiology, 64f.

BACTERIAL DISEASES OF FRUIT TREES.

See V, Plant Pathology, Mycology and Bacteriology, 74.

Plants in sand culture have been inoculated and the results will be observed next year. (W.A.R. and H.W.)

INARCHING TO IMPROVE TREES ON POOR ROOTSTOCKS.

See I, Pomology, 1.

MULCHING.

No mulching was done in 1938. (W.A.R.)

PUBLICATION DURING THE YEAR.

(With Summary.)

Plant Injection for Diagnostic and Curative Purposes. W. A. Roach. Imp. Bur. Hort. and Plantation Crops Tech. Comm. No. 10 (October, 1938), 1-78. (K31.)

1. A review is given of the history of plant injection, which goes back at least to the twelfth century.

2. Methods are described for injecting individual parts of a plant each with a different liquid, using the untreated parts for comparison.

3. The main purpose of these methods is the diagnosis of mineral deficiencies.

4. Such diagnosis may be carried out in as short a time as four days.

5. Some of these methods have a high degree of statistical reliability.

6. Single interveinal areas of certain plants (apple, pear, strawberry, etc.) may be injected so that the permeated area is separated sharply by a secondary vein from the untreated area on either side. This method is not applicable to the peach and the tomato.

7. A leaf after its apical quarter has been amputated may be injected while still attached to the tree by immersing the cut edge.

8. Similar treatment of the leaflet of a compound leaf in some plants (e.g. the strawberry) results in the permeation of one side of the adjacent leaflet, while the other side is not permeated.

9. Injection, through a leaf stalk left attached to the stem after the blade has been removed, results in the permeation of whole leaves and parts of leaves above and below the injection point, the injection pattern depending on the phyllotaxis and the vascular anatomy of the stem. In some leaves the midrib forms a sharp division between permeated and unpermeated blade tissues.

10. Injection through a shoot tip results in the permeation of a number of the terminal leaves.

11. Branches may be injected independently of the rest of the tree through a suitably placed hole passing diametrically through the branch.

12. The individual branches of certain trees may be injected each with a different liquid so that the corresponding roots are also permeated.

13. Whole trees and other plants may be injected through a single diametrical hole, large ones through two or more radial holes.

14. Uniform permeation of all the branches depends on the proper placing of the hole or holes in relation to the branches.

15. Examples are given of experimental or practical applications of all these methods.

V. PLANT PATHOLOGY, MYCOLOGY AND BACTERIOLOGY

PATHOLOGY OF TOP FRUITS.

70. Crown-gall.

Further work on the isolation of organisms from various host plants has been carried out with the object of ascertaining whether the organisms isolated are parasitic and whether the parasite of one host can infect other hosts. Raspberry galls have received attention and further examples of " terminal " galls, where the growing point of a cane is transformed into a gall, have been examined. (H.W.)

Another trial to test the value of an organic mercurial preparation in controlling crown-gall in nursery trees was started in 1938. The trees will be examined in 1939. (H.W. and R.J.G.)

The Etiology of Crown-gall on Apple trees with Special Reference to the apparent Relative Susceptibility of Apple Stocks.

Experiment III (1935 *et seq.*), *Stocks Nos. II, VII and XVI.* (See Ann. Repts. for 1935, 1936 and 1937.) These stocks were grown in the open ground for two years and detailed records were taken but the results have not yet been analysed.

Experiment IV (1937 *et seq.*), *Stocks Nos. II, VII and XVI.* (See Ann. Rept. for 1937.) After taking the records at the end of 1937, these stocks were planted in the open and further growth records taken at the end of this season. They will be kept under observation for a further season before the final records are taken.

Experiment V (1938 *et seq.*), *Stock No. II.* In amplification of Experiment IV, a series of trees (planted January, 1938, in pots) of Stock II, were inoculated at monthly intervals from January to June inclusive. As before, in addition to inoculations with the Crown-gall organism, inoculations on a comparable set of trees (by the same method) were made with a 1 per cent. lanolin paste of α-naphthalene acetic acid. The results at the end of the first year show that, with the growth substance, galls were produced irrespective of the month of inoculation although those treated in April, May and June produced larger galls than those treated in January, February and March, but with the bacterium, those treated in January yielded no galls, those in February two only, while those in the other months yielded many galls. The growth substance caused an appreciable diminution in the amount of new wood produced during the season as compared with the controls and those inoculated with the bacterium.

(R.V.H., H.L.P. and H.B.S.M.)

71. Brown Rot.

The host relationship of the Brown Rot fungi is still under study. In 1938 the Monilia stage of *Sclerotinia fructigena* was found on Medlar fruit. This appears to be the first record of its occurrence on this host in Britain.

A severe infection of cherry shoots resulting in Wither Tip was found to be due to *S. laxa*. (H.W.)

For results of spraying trials against Brown Rot in Morello cherries see under VII, Insecticides and Fungicides.

72. Silver Leaf.

(*a*) Observations are being continued on plum trees with Silver Leaf that have been injected with nutritive and fungicidal substances. (W.A.R. and H.W.)

(*b*) Further study of the relation between Papery Bark Cankers on apple trees and Silver Leaf has confirmed former observations, that *Stereum purpureum* is commonly associated with such cankers, and that the fungus when isolated from apple stems is able to infect plum trees. (H.W.)

73. Influence of Rootstock and Soil Conditions.

In relation to disease, see VII, Insecticides and Fungicides.

74. Bacterial Diseases of Fruit Trees.

Bacterial Canker of Plum Trees.

Field experiments and observations to ascertain the effect of soil conditions on the incidence and intensity of this disease are being carried on. The data on cultural and soil conditions that have been collected in commercial plantations have shown no correlation with the state of the trees as regards this disease. (H.B.S.M. and H.W.)

Observations have been maintained on the plot of Victoria plum trees with stems of various varieties, and of these, Denniston's Gage, Victoria and Pershore have suffered most severely from canker. Purple Egg and Myrobolan B have, so far, had no cankers, and Warwickshire Drooper, President and Utility have had very few. The pruning treatments have, as yet, yielded no results. The effect of the spray treatments is dealt with in VII, Insecticides and Fungicides, 96. (H.B.S.M. and M.H.M.)

It was noted that shot-hole appeared on certain young plum trees in successive seasons and therefore graft-wood was taken from these trees, and also from healthy trees, and grafted on to Myrobolan B stocks to see if infection could be carried by means of the graft wood. Sets of trees are being raised in this way but no results are yet available. (H.B.S.M. and R.J.G.)

The trial of plum trees grown in sand cultures in relation to susceptibility to Bacterial Canker has not yet yielded conclusive results since the cankers arising from inoculations have been too small to show any significant differences. The trees were again inoculated with *Pseudomonas mors-prunorum* in 1938 and the results will come under observation in 1939. (F.H.B., W.A.R. and H.W.)

Results have been published (C143) on the trial of young plum trees in plots receiving various fertilizers, and combinations of fertilizers in relation to Bacterial Canker. No significant differences were found in the size of the cankers on the various plots but there was the suggestion that applications of lime tended to induce susceptibility since, on the whole, the cankers were largest on the limed plots. (H.W. and R.J.G.)

A paper has been published (C144) describing the relation between Bacterial Canker on plum and on certain ornamental shrubs. Organisms isolated from leaves, shoots, and stems of almond and from the stem of the Purple-leaved Plum were found in culture to conform to *Pseudomonas mors-prunorum* and, when inoculated into the

stems of young plum trees, induced the development of cankers, from 6 to 21 cm. in length. (H.W.)

Bacteriosis of Cherry Trees.

The results of cultural and inoculation tests, with organisms isolated from stems, branches, and leaf spots of sweet cherry trees, has been published (C148). The organisms were found to conform to *Pseudomonas prunicola* and *P. mors-prunorum*, the two bacteria which had previously been found to be the cause of diseases in plum trees, and cultural tests for distinguishing the two organisms are described. (H.W.)

A leaf spot disease of Morello cherries was found on trees on this Station in 1938. The lesions contained bacteria and the organism isolated showed affinities, and is probably identical with, *Pseudomonas mors-prunorum*. The organism has been inoculated into branches of Morello, sweet cherry and plum to ascertain whether the Morello may serve as a source of infection for sweet cherries and plums. (H.W.)

Bacteriosis in Pear Trees.

A leaf spot of pear trees has come under observation. From the spots an organism has been isolated which shows relationship with others isolated from wilted pear blossoms and from pear fruits. These organisms are being compared with each other and also with the bacteria of plum and cherry. (H.S.B.M. and H.W.)

PATHOLOGY OF SMALL FRUITS.

75-6. Diseases of Raspberries.

Experiments under these headings were temporarily in abeyance owing to illness. The plant material however has been retained and it is hoped to continue the experiments during 1939. (R.V.H.)

77. Loganberry and Blackberry Diseases.

See XI, Loganberries, Blackberries and Dewberries.

78-9. Strawberry Diseases.

See X, Strawberries.

MISCELLANEOUS.

80a. Verticillium Wilt of Hops.

The survey of affected hop-gardens for disease incidence and soil conditions was continued throughout the year in collaboration with Mr. B. S. Furneaux of the South-Eastern Agricultural College, Wye.

A comparative cultural examination in the laboratory of bines from affected and non-affected gardens was started during the winter of 1937-8.

In July, 1938, at the instance of Kent Hop Growers a special full-time worker was appointed to undertake an intensive study of the disease.

Twenty-eight outbreaks have been reported in Kent and all the affected farms were visited during the season. Many fresh data on the severity and distribution of the disease were collected, on the basis of which the previously recommended measures for control have been considerably modified, and extended as individual cases demanded.

Thus several of the most severely affected farms have started experimental hill-grubbing and preliminary trials in soil disinfection.

Messrs. Whitbreads have placed a piece of infected ground on their Beltring farm at the disposal of the Station for experimental disease control.

A summary of the information to date is given on page 244 of this report.

(R.V.H., W.G.K. and B.S.F.)

80B. A Wilt of Shoots in Layer Beds.

Further observations have been made on the wilting of shoots in varieties of plums and cherries which are being propagated by layering and stooling. Though there was less disease in the main stool beds in 1938 (probably as a result of the dry weather during the summer) than during the two or three years previously, it was again serious in certain experimental plots. The fungus, a species of *Cylindrocladium*, associated with the disease, is being compared with other species of the genus, and material is being raised for a study of the parasitism of the fungus. (H.W.)

PUBLICATIONS DURING THE YEAR.

(With Summaries of Papers not appearing in the last Annual Report.)

Notes on Plant Diseases in 1937. H. Wormald and R. V. Harris. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 181-6. (C141.)

The Crown Gall Disease of Nursery Stocks. III. A Progress Report on Experiments from 1929 to 1937 to determine the Relative Susceptibility of Malling Apple Stocks and including the Production of Galls by Synthetic Growth Substances. R. V. Harris and H. L. Pearse. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 187-93. (C142.)

Manurial Trial on Nursery Trees with Reference to Effect on Plum Bacterial Canker. H. Wormald and R. J. Garner. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 194-7. (C143.)

Two Ornamental Shrubs as Hosts for the Organism Causing Plum Bacterial Canker. H. Wormald. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 198-200. (C144.)

A Bibliographical Note on the Distinction between Mild and Severe Strawberry Crinkle. R. V. Harris. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 201-2. (C145.)

Verticillium Wilt of Hops. A Summary of Information for Growers. R. V. Harris and B. S. Furneaux. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 257-8. (C146.)

Bacterial Diseases of Stone-Fruit in Britain. VII. The Organisms causing Bacterial Diseases in Sweet Cherries. H. Wormald. Journ. Pom. and Hort. Sci., 1938, **16**, 280-90. (C148.)

The organism associated with bacterial lesions on sweet cherry trees in Britain have been found to be *Pseudomonas prunicola* and *P. mors-prunorum*, the bacteria causing similar diseases on plum trees.

Cultural tests for distinguishing the two organisms are described. For quick tests the organisms are grown in nutrient broth with 5 per cent. saccharose, for a colour

difference in the turbidity of the resulting growth, and also in a nutrient agar with 5 per cent. saccharose, for a longevity test. *P. mors-prunorum* (but not *P. prunicola*) dying out within six days.

Inoculation experiments have shown that each organism is able to infect the various parts of a tree liable to attack. Attention is drawn to the relation between the stem canker and the leaf spot phases.

The Septoria Leaf Spot Disease of Black Currants. H. Wormald. Gardeners' Chronicle, 1938, **104**, 2711, 424-5. (C149.)

Mention is made of a severe outbreak of the Black Currant Leaf-spot caused by *Mycosphærella Ribis* (*Septoria Ribis*), near Abersoch, North Wales, in August, 1938. A description of *Septoria Ribis* is given, and the Septoria Leaf-spot is compared with that caused by *Pseudopeziza Ribis* (*Gloeosporium Ribis*). The control measures suggested are those which have been recommended for the Gloeosporium Leaf-spot.

VI. ENTOMOLOGY

81. Red Spider.

Fruit-tree Red Spider.

Methods are being investigated for sampling Red Spider population on the tree. (R.M.G.)

Hop Red Spider.

The life history and control of this pest is being investigated. (A.M.M.)

82. Woolly Aphis.

(*a*) *Testing new seedlings.*

Apple seedlings raised at the John Innes Horticultural Institution, Merton, and at East Malling were tested for resistance to Woolly Aphis, as usual. (R.M.G.)

(*b*) *Causes of resistance, chemical aspect.*

The progress made by the Biochemistry Section in the study of the composition of apple bark will enable entomological work on the principles of resistance to Woolly Aphis to be carried on in the coming season. (J.K.E., R.M.G., A.M.M., W.A.R.)

(*c*) *Causes of resistance, physiological aspect.*

In order to throw some light on the variation of resistance of certain varieties in different places the reproduction rate of the aphis was observed on a series of apple trees grown in sand culture. The results which are not yet conclusive suggest that the rate of breeding of the aphis is not directly affected by deficiency of any particular nutrient element but is possibly connected with the rate of growth of the tree.

83. Chemically Treated Corrugated Cardboard Bands.

This investigation has now been completed, and a report of the work was published in 1938. (D136.) In the 1938 experiments corrugated cardboard bands were used containing various weights of four different treatments, two "Seekay" waxes, tetrachlorbenzene and beta-naphthol.

A "Seekay" wax treatment attracted Codling Moth larvae, tetrachlorbenzene attracted weevils, and beta-naphthol repelled weevils. Other treatments were similar to untreated bands.

The number of insects caught was affected by the variations in the weight of chemicals in the band and by the width of the band. (A.M.M. and R.M.G.)

84. Tortrix Investigations.

Biology and Control of Bramble Shoot Webber. (See 86B.)

85. A Study of the Vectors of "Reversion" of Black Currants.

Material is being raised in order that this investigation may be continued when greenhouse accommodation is available. (A.M.M.)

86A. Mites.

Numerous requests for the determination of species of gall mites have been received from entomologists in Great Britain, Canada, Morocco and Turkey. One species occurring on tomato proved to be new to science and it is being described; another species found on fig leaves is a new record for this country. Other species associated with hardy fruits have been determined. (A.M.M.)

86B. The Insect and Allied Fauna of Rubus.

Lepidoptera.

The life-cycle of the Bramble Shoot Webber (*Notocelia uddmanniana* L.) has been studied in detail, and an account of the work is being prepared for publication. In addition, control measures are being investigated, including the value of an atomized pyrethrum spray which is being tested.

Other species of Lepidoptera which occur on Rubus are being investigated. (G.H.L.D.)

Aphididae.

The life-cycles of the species of Aphides which are associated with Rubus have been worked out, and a comprehensive report is ready for publication. Investigations are proceeding to determine whether the Rubus aphides are carriers of the virus diseases of raspberry and blackberry. (G.H.L.D.)

Coleoptera.

Certain species of Coleoptera have been kept under observation, and the damage caused by them to various species of Rubus has been noted. The Weevil, *Rhynchites germanicus* Hb. is widespread, and it damages the young canes of raspberry by girdling them. (G.H.L.D.)

86C. Insects associated with Hops.

A preliminary survey of the insects commonly found feeding upon the hop has been made in 1938, with special reference to certain species which feed on the leaves. (A.M.M.)

86D. Hop Mosaic—Insect Transmission.

Preliminary investigations have been started to determine whether one or more of the insects found on hop is associated with the spread of mosaic in the field. Initial inoculations have been made to determine whether the hop aphis and a species of flea beetle are "carriers" of the virus. The results of this investigation are not yet available. (A.M.M.)

87, 89, 90, 91. Strawberry Insects and Mites, Virus Transmission.

See special report on Strawberries under X.

88. Raspberry Mosaic, Insect Transmission.

See special report on Raspberries under IX.

PUBLICATIONS DURING THE YEAR.

(With Summaries of Papers not appearing in the last Annual Report.)

The Fauna of the Weevil " Sackband ". III. A. M. Massee and R. M. Greenslade. Ann. and Mag. Nat. Hist., Series XI, 1938, **1**, 607-10. (D132.)

A list is given of the species of insects found in corrugated cardboard trap bands. One hundred additional species are noted, bringing the total up to two hundred and sixty.

Coleoptera associated with cultivated fruits. A. M. Massee. Trans. Soc. for Brit. Ent., 1938, **5**, 223-34. (D133.)

A list is given of the Coleoptera associated with cultivated fruits and hops. Special reference is made to the species of economic importance and brief details of damage caused by them is outlined.

Notes on Some Interesting Insects Observed on Fruit Trees in 1937. A. M. Massee. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 203-8. (D134.)

Notes on the Strawberry Aphid (*Capitophorus fragariae* Theob.). A. M. Massee, R. M. Greenslade and A. J. Duarte. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 209-12. (D135.)

Studies of Impregnated Tree Banding Materials. IV. Apple Blossom Weevil and Codling Moth Experiments in 1937. A. M. Massee, R. M. Greenslade and A. J. Duarte. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 213-18. (D136.)

VII. INSECTICIDES AND FUNGICIDES

LABORATORY INVESTIGATIONS.

93, 99, 100. Insecticides.

Tests of Ovicides.

The investigation of the toxic properties of tar and petroleum distillates has been continued. Further data on the influence of physical and chemical properties upon toxicity have been obtained and the tentative correlation of properties has been largely confirmed. Attention has been given to various analytical problems that have arisen directly from this work.

The newer organic ovicides, including thiocyanates and nitrophenols, have been tested against a wider range of insect eggs and further promising results have been obtained. 3 : 5-Dinitro-*o*-cresol again proved to be the most generally toxic substance tested. A report of this work has been published (Q13) and a summary is given below. (H.S. and W.S.)

Physiological Aspects.

Preliminary investigations on the physiology of ovicidal action have been carried out with the aid of the Department of Entomology of the Imperial College of Science. (W.S.)

100. Fungicides.

Chemical Aspects.

As a part of the effort to identify the factors responsible for the damage caused by combined sprays containing lime-sulphur, it has been shown in the case of lime-sulphur-lead arsenate mixtures that the amount of soluble arsenic liberated from a given amount of lead arsenate decreases as the concentration of lime-sulphur increases. (H.S.)

FIELD INVESTIGATIONS. I.—MODIFICATION OF ROUTINE CONTROL MEASURES.

94, 100. Influence of Supplements on Retention of Spray Residues.

Another field spraying trial was carried out to determine the effect on the deposition and retention of arsenical residue of the addition of oil emulsion and lime-sulphur to a lead arsenate spray. Evidence was obtained that the apparent loss of deposit from the surface of apples is due to growth of the fruit and not to weathering. In other respects the results were not conclusive. (See p. 199.) (H.S. and W.S.)

96a. Insecticide-Fungicide Programme for Cox's Orange Pippin and Worcester Pearmain.

Although Scab was prevalent in 1938, infection was reduced to almost negligible proportions where lime-sulphur was applied five times, at green-bud (2 per cent.), pink-bud (1½ per cent.), petal-fall (1 per cent.), and twice more at two-week intervals (½ per cent). Slightly inferior control was obtained where, with the same pre-blossom

sprays, only two sprays, each at 1 per cent., were given post-blossom, one at petal-fall and the other three weeks later. A very early flowering season caused post-blossom sprays to assume more than usual relative importance, for ascospore infection occurred mainly at blossom time. The crop of Cox's was drastically reduced by spring frosts, but confirmation of the results was forthcoming from the Worcesters, which cropped much better. Coupled with drought, the post-blossom sprays at either strength caused leaf-drop on Cox's, two at ½ per cent. being ultimately as harmful as one at 1 per cent. On headland trees, the standard lime-sulphur programme of four sprays, two pre-blossom at 2½ per cent., and two post-blossom at 1 per cent., gave slightly better control but caused more leaf-burn than the similar programme based on weaker pre-blossom sprays, where leaf-burn was only slight. The residual fungicidal value of the pre-blossom sprays was probably of enhanced importance in this abnormal season. Infestation by Sawfly and Codling was negligible ; nicotine (0·05 per cent.) was included on all trees at petal-fall to control the former, and lead arsenate powder (0·2 per cent.) in the final post-blossom spray to control the latter.

In another small trial, on Cox's, in which Bordeaux mixture (4-6-100) with lead arsenate powder (0·2 per cent.) was used instead of lime-sulphur at green-bud, and was followed by lime-sulphur at pink-bud and three times post-blossom, severe burning of the rosette leaves was observed, but the effect on the fruit and on Scab was inconclusive owing to frost injury and virtual lack of Scab. The burning of the rosette leaves was only slight where lime-sulphur (1 per cent.) with lead arsenate powder (0·2 per cent.) was used at green-bud, but here the leaves were smaller than those on similar unsprayed trees. The tendency of lime-sulphur to cause "little leaf" has frequently been observed. (M.H.M.)

96. Mitigation of Spray Damage.

By addition of cotton-seed oil.

Confirmation was obtained that the inclusion of cotton-seed oil at 0·75 per cent. with weak Bordeaux mixture (1-1½-100) prevented foliage injury on Worcester Pearmain and slightly increased very mild fruit-russeting. Results on Scab-control were inconclusive owing to light infection, and cropping was impaired by severe spring frosts. That this weak Bordeaux mixture caused only very slight injury in 1938, though very severe on Worcester on No. IX rootstock in 1937, is considered to be due to the transference of the trial to trees on another rootstock (No. II) and planted on a different, unmanured plot, and to the different seasonal conditions in the two years. In spite of this change of circumstances, the relationship between the amount of damage caused by the Bordeaux with, and that without, oil was similar in each season. (M.H.M.)

By reduction in spray concentration.

Under 96A above, it will be seen that a spray-programme including lime-sulphur used twice pre-blossom at 2½ per cent. gave slightly better Scab-control but more leaf-burn than one in which this spray was applied at the same two periods at 2 per cent. and 1½ per cent. respectively. On another plot reported under 96 (Fungicide Trials) below, lime-sulphur used not stronger than 1 per cent. at any of five periods, two pre- and three post-blossom, gave almost complete control of Scab on four varieties and caused no more injury than very slight burning of the leaf-tips and, on Newton Wonder, slight yellow-leaf and leaf-drop.

In the trial of Bordeaux mixtures referred to above, where a series of different strengths ranging from 1-1½-100 up to 6-9-100 was tested on Worcester Pearmain, all

of the sprays caused injury, which became the more severe with increase in strength of spray. The use of burnt (4-4-100) instead of hydrated lime (4-6-100), and of excess hydrated lime (4-12-100) in place of the normal (4-6-100) failed to effect a worth-while reduction in injury, although there was slightly more fruit russeting with the 4-6-100 spray than with either of the two others. The spray made with burnt lime caused slightly less leaf-burn than either of the two others. Results in Scab control were not conclusive owing to the virtual absence of infection. (M.H.M.)

96. Effect of Sprays on Apple Blossom.

Severe spring frosts, by killing the blossom, greatly interfered with the after-effects on cropping in 1938 of blossom sterilization by spraying in 1937, and thus hindered this study of blossom spraying in relation to biennial bearing (see I, Pomology, 13, and III, Plant Physiology, 64 (*h*), Biennial Bearing). In spite of the frost, however, there were distinct indications that on Cox's Orange Pippin trees (on No. IX) where fertilization was most drastically impaired by spraying with lime-sulphur, *inter alia*, in 1937, there was, in 1938, a greater set of fruit than on trees where fertilization was not so severely impaired. This suggests promise that a carefully selected blossom spray may ameliorate the biennial bearing habit, and further work is contemplated on this aspect as well as on that concerning Scab control. In another small trial on Cox's on No. II, which also was nearly ruined by frost, lime-sulphur used at 1 per cent. or $\frac{1}{2}$ per cent. at blossom time reduced the blossom-set, the stronger spray having slightly the greater effect. Data on Scab control were inconclusive owing to light infection. (M.H.M.)

FIELD INVESTIGATIONS. II.—TESTS OF NEW SPRAY MATERIALS.

94, 99, 100. Winter Washes.

Further field spraying trials were carried out against the eggs of Leaf Curling Plum Aphis (*Anuraphis padi*) and the Hop-Damson Aphis (*Phorodon humuli*). The results agreed with laboratory findings but were marred to some extent by the very low resistance of the eggs used.

A report of some of this work has been published (Q13). (H.S. and W.S.)

96. Fungicide Trials.

A full report on the investigations made in 1937 has been published (Q12). In 1938, further tests were made on Worcester Pearmain, Cox's Orange Pippin, Allington Pippin and Newton Wonder trees on No. IX stock, and sprays were applied twice pre- and twice, sometimes three times, post-blossom. Frost nearly ruined the trial by greatly reducing the crop. Records of Scab were obtained on leaves as well as fruits, and again an all lime-sulphur programme gave the best results. Five applications, viz. at green-bud (1 per cent.), pink-bud (1 per cent.), petal-fall (1 per cent.), and two more ($\frac{3}{4}$ per cent.) at two-week intervals, proved rather better than four, where one application (1 per cent.) three weeks after petal-fall was substituted for the two last in the above programme. Little damage accrued, some yellowing and dropping of the oldest Newton leaves in early June being the most noteworthy. A satisfactory alternative, although rather less effective, post-blossom spray, following lime-sulphur pre-blossom, was colloidal sulphur (0·5 per cent.), which proved safe. A zinc-lime (8-12-100) mixture, similar to Bordeaux, was the fungicidal equal of colloidal sulphur, but it caused fruit-russeting and leaf-drop on Allington. Tetramethylthiuram disulphide (0·05 per cent.) was safe but less effective than colloidal sulphur. Two pre-blossom

lime-sulphur (1 per cent.) sprays alone gave no appreciable control of Scab. This very unusual result is explained in that primary infection did not occur pre-blossom because of the exceptionally early season, and it was thus removed, in the main, from the influence of pre-blossom spray treatment. The control trees were heavily infected.

(M.H.M.)

FIELD INVESTIGATIONS. III.—BIOLOGY AND CONTROL OF SPECIFIC PESTS AND DISEASES.

92, 94. Codling Moth.

In two field trials this pest was adequately controlled by a late June application of lead arsenate. Derris root reduced the attack somewhat but was less effective than lead arsenate.

(W.S.)

94. Red Spider.

Evidence that adult mites can spread from tree to tree was obtained by hanging greased plates in the orchard. (W.S.)

96. Brown Rot in Morello Cherries.

Dry weather at blossom time resulted in only light infection, even on control trees. A new trial was begun on trees previously used for spraying trials against this disease. Hence all trees were first sprayed with tar-oil emulsion (3 per cent. strained anthracene oil) to burn up any brown-rot pustules on them, and a known number of pustule-bearing, dead shoots were tied on to each tree in the trial. The trees were then differentially sprayed, early in February, and there were adequate unsprayed controls. In spite of the light infection, a spray containing 3 per cent. neutral tar oil + 0·25 per cent. tar acids or 3 per cent. neutral tar oil + 0·25 per cent. petroleum oil, and emulsified with soap solution, showed to slightly better advantage than one containing only the emulsified 3 per cent. neutral tar oil, which, however, reduced infection when compared with that on the controls. There was no more infection on trees sprayed with either of the two first-named treatments than on unsprayed trees, with no tied-on shoots, used to buffer the spray-treatments. This small degree of infection may therefore represent the minimum and be due to " wild " sources. The trial will be repeated in the hope that greater infection will lead to more definite results. (M.H.M.)

96. Fusarium Bud-Rot.

The parasitism of a fungus tentatively regarded as *Fusarium lateritium* Nees var. *fructigenum* (Fr.) Wr., which has been assumed to be the cause of this disease, was proved by inoculation experiments on a Grenadier apple tree in the field. The buds were inoculated on 27th January, 1938, by spraying them with spore-suspension from an atomizer or by injecting them with spore-suspension from a hypodermic syringe. They were afterwards covered with glass specimen tubes or with celluloid cylinders, the open ends in each case being plugged with moist sphagnum moss. A similar series of inoculations was done on cut shoots of Grenadier in the laboratory, but gave less definite results because the shoots wilted at bud-burst. Spore-suspensions were obtained from pure cultures from two sources, viz. infected buds of Grenadier and of Bramley's Seedling apple trees, and inoculations with each were successful.

The experiments were initiated because first symptoms similar to those caused by the Bud-Rot fungus can be caused also by certain kinds of sprays, notably tar-oil or petroleum-oil emulsions, and it is sometimes difficult to determine the primary cause. The buds in these experiments had not been sprayed with either fluid.

(M.H.M.)

96. Bacterial "Shot-hole" and Canker in Stone Fruits.

There were relatively few cankers and "bud-infections" in 1938, but leaf-spot infections were more prevalent than usual on the Bigarreau de Schrecken cherry trees in this experiment. Application of Bordeaux mixture both in autumn (at 10-15-100) and in spring (at 6-9-100 just pre-blossom; 4-6-100 with cotton-seed oil 0·75 per cent. at petal-fall) again gave the most efficient control of cankers and "bud-infections". Two applications at either period proved better than one (the earlier in each case) but not where autumn and spring sprays were combined; this is not in accordance with previous findings and probably denotes seasonal influence, particularly rainfall. Single application in autumn only or in spring only was not very effective. The best control of leaf-spot was given by the two spring sprays, infection being greatly reduced. The single, pre-blossom, application was slightly effective, but autumn application gave no control. The inclusion, post-blossom, of the cotton-seed oil rendered Bordeaux safe on the foliage at 4-6-100 and nearly so at 6-9-100. Without oil each spray, particularly the latter, caused considerable leaf-burn. Spraying Schrecken trees in full bloom with Bordeaux (4-6-100) to test its effect on cropping was inconclusive as the blossoms were nearly all sterilized by frost.

Rootstock effect on the incidence of cankers was not very clearly defined on account of light infection and of the rather small units of trees on each stock.

In a cumulative spraying trial on young, double-worked Victoria plum trees, Bordeaux mixture (10-15-100) applied once in autumn has so far effected slight reduction in the number of canker infections which, except where Victoria and Denniston's Gage are the intermediate rootstocks, have not been really numerous even on control trees. Of two Bordeaux sprays in spring, 1938, each at 4-6-100, the second, applied about three weeks after petal-fall, provided marked control of the leaf-spot phase and also of Plum Rust (*Puccinia Pruni-spinosae*), while causing only slight spotting of the leaves and no leaf-drop; a spray even later would probably give much better control of the Rust which, where severe, caused premature defoliation. A petal-fall application had little apparent effect on disease or on spray damage. (H.B.S.M. and M.H.M.)

97. Apple Scab.

A trial was started in 1937 to determine the influence of differential manuring with artificials on the incidence of disease, chiefly Apple Scab. The varieties concerned are Worcester Pearmain, Cox's Orange Pippin, Allington Pippin and Newton Wonder, all on No. IX rootstock. The trial is designed to compare "no manure" with nitrogen, applied as sulphate of ammonia at 3 cwt. per acre, and with potash, as sulphate of potash at 3 cwt. per acre. In the first year the artificials only were applied, but in 1938 a basic dressing of humus was given at 11½ tons per acre, and the artificials were superimposed. All insect pests are controlled as much as possible, but fungous diseases are allowed to develop for observation. There was an extremely heavy attack of Scab in 1938, but it is clear that the manures have as yet scarcely had time to influence resistance or susceptibility to any marked extent. There is, however, in the data obtained, a suggestion that the fruit from trees receiving nitrogen only were rather more scabbed than the others. Cropping was greatly reduced by frost. (M.H.M.)

The injection of certain nutrient solutions into Cox's Orange Pippin trees failed to give results on the incidence of Apple Scab owing to lack of infection on the leaves and the destruction of the crop by frost (see IV, Biochemistry, 68(x) Results of Injection, page 73). (B.F.G.L. and M.H.M.)

97A. Branch-Blister Disease.

Mention was made in last year's Report of a pot experiment designed to show the influence of controlled relative drought and of dressings of sulphate of potash on the incidence of this disease. The trees, Cox's Orange Pippin on No. IX rootstock, have been establishing themselves in the pots during 1938, and they have been well watered. Differential potash manuring has already been practised and the differential watering under controlled conditions will be initiated in spring, 1939. The pathology and pomology issues in this experiment are being studied in collaboration (see I, Pomology, 25, Irrigation, page 47). (M.H.M. and W.S.R.)

96. Loganberry Cane Spot.

A further collaborative spraying experiment was carried out, the results of which are reported under XI, Loganberries, Blackberries and Dewberries, 77B, page 100. (A.B.B., R.V.H. and M.H.M.)

PUBLICATIONS DURING THE YEAR.

(With Summaries of Papers not appearing in last Annual Report.)

Spray Residue Investigations. II. The Influence of Spray Supplements on the Retention of Lead Arsenate on Apples. H. Shaw and W. Steer. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 219-22. (Q10.)

Experiments on the Control of Plum Sawfly on Czar Plums. W. Steer and A. A. G. Hassan. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 223-8. (Q11.)

Field Trials in 1937 of the Fungicidal and Phytocidal Properties of Certain Sprays used against Apple Scab. A Progress Report. M. H. Moore. East Malling Res. Sta. Ann. Rep. for 1937 (May, 1938), 229-35. (Q12.)

Studies on the Toxicity of Certain Nitrophenols, Thiocyanates, Naphthalene Derivatives and Organic Bases to the Eggs of Some Common Orchard Pests. H. Shaw and W. Steer. Journ. Pom. and Hort. Sci., 1939, **16**, 264-88. (Q13.)

The ovicidal properties of forty-four organic preparations, most of them chemically individual substances, have been investigated in the laboratory using as test objects the eggs of the Vapourer Moth (*Orgyia antiqua* L.), the Green Apple Aphis (*Aphis pomi* De Geer), the Winter Moth (*Operophtera brumata* L.), the Fruit-tree Red Spider (*Oligonychus ulmi* C. L. Koch), and the Apple Sucker (*Psyllia mali* Schmidt). The preparations were mainly dinitrophenols, thiocyanates, naphthalene derivatives and organic bases. 3 : 5-Dinitro-*o*-cresol, *n*-dodecyl thiocyanate (lauryl rhodanate), β-butoxy-β′-thiocyanodiethyl ether and nicotine were the most toxic and the first named was outstanding. Wherever sufficient data were available, attempts have been made to correlate differences in toxicity with modifications of molecular structure.

The four materials mentioned were further tested in field trials on plum trees infested with Leaf-Curling Plum Aphis (*Anuraphis padi* L.) and Hop-Damson Aphis (*Phorodon humuli* Schr.) and largely bore out their laboratory promise.

The mechanism of the ovicidal action of nicotine is discussed in some detail.

Leaf Blight on Medlar in England. M. H. Moore. Gardeners' Chronicle, 1938, **104**, 440-1. (Q14.)

A severe outbreak of Medlar Leaf Blight, caused by the fungus *Entomosporium maculatum* Lév., is reported in 1938 on the foliage of a Medlar tree growing in a private garden at West Malling, Kent. A brief summary of the literature of the fungus is included.

VIII. EXTERNAL CONTACTS

101. Enquiries and Visitors.

The number of letters written in the course of the year in answer to enquiries amounted to 1,642. Visitors to the Station numbered 3,248 including 190 visitors from overseas and 57 organized parties.

(N.B.B., H.C.C., H.B.S.M., B.G.L. and the staff in general.)

102. Conferences, Demonstrations, Lectures and Exhibits.

Two conferences and three open days have been held and twenty-two lectures given by members of the staff. Ten educational exhibits have been staged. For further details of External Contacts see the Supplementary Annual Report (twenty-sixth year), General Development and Activities. (Misc. Pub. A22.)

PUBLICATIONS DURING THE YEAR.

(With Summaries of Papers not appearing in last Annual Report.)

The Cultivation of Fruit. N. B. Bagenal. Gardening Illustrated, 1938, **60**, 3113. (E145.)

A popular article on soil, situation, rootstocks and manuring for different fruits.

Apples for the Garden. N. B. Bagenal. Gardening Illustrated, 1938, **60**, 708-9. (E147.)

A popular article on some varieties of cooking and dessert apples suitable for garden culture with notes on each.

Notes from East Malling Research Station—Inarching. N. B. Bagenal. Guildford and District Hort. Soc. Monthly Journ., 1938, **13**, 5-7. (Eg12.)

A short note on the technique of inarching one or more vigorous rootstocks into the stem with the object of restoring vigour to weak or stunted fruit trees.

IX. RASPBERRIES

(*Combined Pomological and Pathological Investigations.*)

42. Variety Trials.

Two named varieties were added to the collection during the past year. A new, and it is hoped more vigorous, stock of Pyne's Royal was also obtained as a very welcome gift from a member. On the other hand, twenty-four varieties, found to be of neither experimental nor commercial value, were destroyed.

The frosts of April and May killed a large proportion of the early blossom of all varieties. As in 1935, there appeared to be wide differences in blossom hardiness; Lloyd George again proved to be one of the least hardy, whilst several American varieties, and particularly Newburgh, were much less injured. (N.H.G.)

47. Breeding.

The seed sown in August, 1936, continued to germinate in small numbers in 1938, but the final germination was still very poor, in no case reaching 40 per cent. The growth of the plants in the seedling bed has, however, been generally good. Many of the plants raised by crossing Newburgh with certain seedlings, in particular, seem likely to have the fault of producing too much spawn. None of these plants have yet produced enough fruit for description; most of them should give some idea of their merits in 1939.

The seedlings planted out in 1936 gave a moderate crop, in many cases much reduced by the frosts of April and May. As would be expected, frost injury to blossom was usually most severe amongst the early blossoming seedlings. But there were exceptions; both early blossoming forms with little injury, and late blossoming forms much injured, were found. The five red-fruited families (the sixth is a "purple cane" family, having Naples black raspberry as one parent) vary greatly in their proportion of promising seedlings.

The three seedlings so far regarded as the most promising of the older families were all very severely injured by frost, and produced very few secondary flowering shoots; consequently they bore little fruit. It may be noted, however, that they are all planted in a position long known to be frosty. (N.H.G.)

50. Propagation.

The plants on the mosaic-free propagation plot were transferred, early in 1938, to fresh ground, and made excellent growth in the first year. Nine named varieties and eight seedlings were planted; preparations have been made to add two more named varieties and five more seedlings in the winter of 1938-9.

In addition, a second propagation plot was established for those varieties believed to be either unobtainable free from mosaic, or symptomless "carriers". Thirteen named varieties have so far been planted, mostly for use in experimental work on mosaic. (N.G.H. and R.V.H.)

59. Manuring.

In the fourth year of the combined seedling and manurial trial the crop of fruit, owing to the spring frosts, was only moderate. A count of the injured blossoms showed that, whilst there were considerable differences between the varieties, the manurial treatment did not seem to have affected blossom hardiness.

Cane growth generally was more vigorous than in previous years, with the exception of Seedling C, which appears to be falling off in vigour.

The order of the manurial treatments in cropping was the same as in the previous year, although the differences were not quite significant. The treatment consisting of 2½ cwt. of sulphate of potash every year gave the largest crop, then that of 2½ cwt. in alternate years, and lastly two treatments, 2½ cwt. in the first year only, and 10 cwt. in the first year only. Sampling for fruit size showed that there were no significant differences with treatment.

Three of the seedlings, A, B, and C, cropped significantly more heavily than Lloyd George and MacLaren's Prolific. The fourth seedling, D, bore slightly, though not significantly, less fruit than Lloyd George, but both bore significantly more than MacLaren's.

In fruit size, all four seedlings were significantly larger than either named variety ; as in previous years, seedling C bore the largest fruit, and MacLaren's the smallest.

MacLaren's Prolific and Seedling A have still shown only occasional faint symptoms of mosaic. Lloyd George and Seedling C are becoming rapidly infected in all parts of the plot, whilst Seedlings B and D show a somewhat lower rate of infection.

(W.A.B. and N.H.G.)

75B. Non-Parasitic Disorders.

Experiments under this heading were temporarily in abeyance owing to illness. The plant material, however, has been retained and it is hoped to continue the experiments during next season. (R.V.H.)

76. Raspberry Virus Disease.

Transmission.

A mosaic infection trial under field conditions, planted partly in 1935-6, and partly a year later, has begun to yield interesting results. In rows where each stool is double, consisting of a mosaic-free " indicator " variety and a suspected " carrier " variety, certain of the indicator plants have become infected. In addition, two out of ten mosaic-free plants of the American variety, Cuthbert, planted in the same stool with infected plants of Ranere, have shown symptoms closely resembling those of Cuthbert mosaic as seen in Canada. So far as is known, this is the first record of the field transmission of mosaic from one American variety to another in England.

(N.H.G. and R.V.H.)

Experiments in Commercial Control.

Inspections and " roguings " of mosaic-free propagation plots at East Malling, and (in collaboration with the County Horticultural Staffs) in Kent, and East and West Sussex, have again been carried out with generally satisfactory results.

Owing to the transfer of the East Malling propagation plot to new quarters (see 50 above) only a few dozen mosaic-free canes were this year available for distribution.

(N.H.G. and R.V.H.)

86b. The Insect and Allied Fauna of Rubus.

See special report on Entomology VI.

88. Raspberry Insects.

A study of the biology of the aphides associated with Rubus has been continued, and more details of the life cycles of the species feeding on raspberry have been obtained.

Further work on the transmission of mosaic diseases by means of aphides were made again in the summer months, four species more usually associated with raspberry being used in these experiments. (G.H.L.D. and A.M.M.)

X. STRAWBERRIES

(*Combined Pomological and Pathological Investigations.*)

44. Classification, Nomenclature and Variety Trials.

Clonal races of important varieties have been kept under observation, and a preliminary trial of new selections has been started. A 6-acre field of Royal Sovereign has been planted for a commercial trial. (W.S.R.)

48. Breeding.

Several families of seedlings raised from crosses between *Fragaria chiloensis*, *F. virginiana* and *F. vesca* have been planted out for fruiting and, at the end of the coming season, a selection of the most promising plants will be made from them for further intercrossing. It is hoped, by continued interbreeding seedlings from these species crosses, to evolve varieties of commercial value that will either be immune from virus infection or will have characters which will facilitate its early recognition. Observations have been continued on a series of plants selected and propagated from crosses between Royal Sovereign, Cessnock and Marcienfelde, raised at the John Innes Horticultural Institution. (H.M.T.)

Arrangements have been made, in collaboration with the Entomological section, to start upon a programme of breeding and testing seedlings for resistance to, or immunity from, Strawberry Aphis. Since this insect is known to be one of the chief vectors of Yellow-edge disease, the discovery of seedlings of commercial value immune from this insect may prove an effective method of combating the virus. A number of plants will be ready for entomological testing during the coming spring.

(H.M.T. and A.M.M.)

52. Propagation.

On account of the great demand, runners of our clonal Royal Sovereign were raised on some 12 acres of " Isolated Block " runner beds. Plants showing " Severe Crinkle " symptoms, as well as those showing " Yellow-edge ", were included in the routine roguing this year, causing a total loss by roguing of about 5 per cent. of the plants. In consequence, we hope that the plants sent out in 1938-9 are still better than those distributed previously. The crop of runners from autumn-planted beds was much higher than that from spring-planted beds.

Some new " virus-free " clones of Royal Sovereign have been collected, and are undergoing a preliminary trial. Another attempt is also being made to start " virus-free " clones of several other important varieties.

New runner beds have been planted on several different plans, in an attempt to find a method which, while retaining the " Isolated Block " principle, will lessen the roguing losses, and the amount of hand labour required for laying in and weeding.

A review of recommendations for raising and maintaining healthy plants appears on page 223. (W.S.R., R.V.H. and M.E.K.)

The Establishment of Clones of Vigorous "Carrier" Varieties.

Since some of the virus "carrier" varieties such as Mme Lefebvre and Huxley are of particular value in areas where clean "susceptible" varieties become rapidly re-infected with virus, an attempt is being made to raise improved clones of certain "carrier" varieties in an isolated part of the Station. It must be emphasized, however, that we cannot expect, at present, to raise even relatively "virus-free" stocks of these varieties, and they must not be grown near "susceptibles" like Royal Sovereign or Paxton. Particularly careful aphis control measures will be used on these beds. (W.S.R.)

Individual Plant Studies of Clonal Families.

This work has been published. (See p. 62.) (W.S.R. and J.L.E.)

Effect of Age of Parent.

A new trial comparing runners from one- and two-year-old parents has been planted. (W.S.R.)

57. Planting, etc.

Time of Planting in Relation to Warm Water Treatment.

This series of experiments has now been concluded, and the results will shortly be written up. (W.S.R.)

Effect of Planting Strawberries after Strawberries.

The data on this trial will now be summarized and published. (W.S.R.)

Burning in Relation to Pest Control and Cropping.

In the second of these trials, as in the first, there was a larger crop on the plots where the litter was burnt after fruiting, in the previous year, than on those not burnt over, although plant size was slightly reduced. This treatment is evidently worth serious consideration. A further trial on a larger scale is planned. (W.S.R. and A.M.M.)

Distance of Planting.

The crop of this trial was much reduced by the spring frosts of 1938, for nearly 40 per cent. of the blossoms were destroyed. Nevertheless, a fair crop was harvested, and the results in a dry summer were in interesting contrast to those of the wet summer of 1937. The close spaced plants gave little more crop than the medium spaced plants. This work will be written up shortly. (W.S.R.)

Irrigation.

Artificial irrigation equal to 1 inch of rain was applied by the spray method to certain plots soon after picking commenced, when the soil moisture tension was 45cm. Hg, and resulted in a 70 per cent. increase in amount of first grade fruit, and a 27 per cent. increase in total fruit weight. The spray method gave much better water distribution than the furrow method used in 1937. This work will shortly be written up. Watering was also carried out on a small area of runner bed, and resulted in increased runner production. (W.S.R.)

60. Manuring.

The manurial trial, comparing various complete top-dressings, gave a fair crop in 1938. Meat-and-bone meal gave the best results.

In another trial, little difference was shown in 1938 between plots receiving farmyard manure in 1936 and those receiving none, the effect apparently having become exhausted in 2 years. Both of these trials are now ready for report. (W.S.R.)

78. Virus Diseases.

Field Experiments.

Field studies of Yellow-edge symptoms on Royal Sovereign have been continued and previous results confirmed. In addition a new comparative trial of a Yellow-edge free and a mildly infected clone with other severely infected clones has been begun. There have been consistent differences in the behaviour of plants from the mild and severely infected clones, the latter being smaller and showing more drastic symptoms. The data on a possible protective action by mild Yellow-edge against reinfection by severe Yellow-edge are as yet inconclusive.

The experiment in which the spread of Yellow-edge virus was observed under different manurial conditions and with various control measures was continued during the year. Plant to plant records of symptoms of disease and vigour were made as in previous years. Unfortunately the incidence of virus infected aphides both from untreated plots and from outside sources caused such a widespread infection that the local spread of disease within the plots was obscured. The experiment has now been concluded and the various data are being analysed.

(R.V.H., W.S.R., A.M.M. and M.E.K.)

Transmission Experiments for Analysis of Symptoms.

1. *Fragaria vesca as an Indicator of Virus Diseases.* The woodland strawberry *F. vesca* readily shows symptoms of virus diseases when grafted to an infected plant, and can therefore be used as an indicator of the virus content of other varieties of strawberries. During 1938 a series of experiments has been carried out with samples of various apparently healthy commercial varieties collected from different sources. Many of these varieties were found to be infected with Mild Crinkle and some with Yellow-edge as well. Several samples of the variety Royal Sovereign, received from western Ireland, proved to be entirely virus-free. These will be of very great value as a source of healthy experimental material for future experiments in the study of Yellow-edge and Mild and Severe Crinkle viruses. (R.V.H. and M.E.K.)

2. *Strains of Yellow-edge Virus.* Previous work had suggested the existence of multiple strains of Yellow-edge virus, some milder in effect than others. Experiments were designed to test this hypothesis using stolen grafting and aphides as methods of transmitting the virus. The results were inconclusive owing to delay in the appearance of symptoms and the experiments will be repeated next year.

(R.V.H., A.M.M. and M.E.K.)

3. *Mild and Severe Crinkle.* A preliminary experiment was carried out to study the etiological distinction between Mild and Severe Crinkle, using material which was already infected with Mild Crinkle. Future work on this point will be greatly facilitated by the supply of entirely Crinkle-free plants which has become available during the year. (See under 1 above.) (R.V.H., A.M.M. and M.E.K.)

Nutritional Studies.

The question of a relation between symptom expression and soil variation was studied by comparing the symptoms developing on uniformly infected plants grown

in three entirely different soils. Series of clonal Yellow-edge free Royal Sovereigns, clonal Yellow-edge infected Royal Sovereigns and clonal healthy *F. vesca* were potted in ordinary greenhouse compost, Irish bog-peat and woodland soil. Some of the healthy *F. vesca* were infected with Yellow-edge by means of aphides and others by stolon grafting. No difference in type and intensity of symptom expression on Royal Sovereign or *F. vesca* was recorded between any of the treatments. Aphides were able to infest *F. vesca* plants on all soils and transmit the disease to them, thus providing evidence that the immunity of *F. vesca* towards aphis attack under natural woodland conditions cannot wholly be attributed to the nature of the woodland soil. This result was confirmed by an experiment carried out in the wood itself.

A piece of woodland was cleared, enclosed, cultivated and planted with clonal Yellow-edge free Royal Sovereign and *F.vesca* plants. Aphides spread to all the plants during the migration period and infected some of them with Yellow-edge. On the other hand aphides were not found on any plants which were growing undisturbed in their normal mat of woodland vegetation, although some of these were situated in the ground adjoining the cleared and cultivated plot of infested plants. These results show that aphides will feed on *F. vesca* growing in woodland soil when that soil is cleared of other plants and cultivated. (R.V.H., A.M.M., R.M.G. and M.E.K.)

87. The Strawberry Tarsonemid Mite.

Control.

Investigations have been continued in the field to control the mite by means of sprays and dusts. The treatment of mite-infested plants prior to planting is also being studied. (A.M.M. and R.M.G.)

89. Strawberry Aphis Investigations.

Aphis Transmission Experiments.

In 1937 it was established that the aphis *Capitophorus fragariae* Theo. is a vector of the Mild Crinkle virus disease. This experiment was repeated in 1938, and the results obtained in the previous year were confirmed.

Experiments are in progress to ascertain the period of time necessary for a viriferous aphis to feed on a healthy plant, in order to transmit the Yellow-edge virus of strawberry.

It has been shown in recent experiments by Harris that *Fragaria chiloensis* is a symptomless-carrier of Yellow-edge and Crinkle. More recently it has been established that the strawberry aphis can readily transmit the Yellow-edge and Crinkle virus diseases from *F. chiloensis* to *F. vesca* and Royal Sovereign. This has been proved by means of a direct inoculation experiment. (A.M.M.)

Life Cycle.

Further observations have been made on the life history of the aphis with particular reference to the migrating generations. The migrating aphis can find isolated strawberry plants amongst other crops and will find and colonize wild strawberry plants growing in cultivation. (R.M.G. and A.M.M.)

Control.

The use of atomized sprays for the control of strawberry aphis has been tried. Though not yet comparable in value with nicotine and soft soap spraying the results justify further work. (R.M.G. and A.M.M.)

Estimation of Aphis Population in the Field.

A method of sampling aphis population on strawberry has been worked out and a report will be published. (R.M.G.)

90. Insects Feeding Upon the Strawberry Plant.

A survey is being made of the fauna of strawberry, and the more common insects are being studied. (A.M.M.)

91. Warm Water Treatment.

The use of the warm water treatment is being continued whenever the presence of mite is suspected, since this is the only effective commercial means of control yet available ; but possible alternatives are being investigated. (A.M.M. and W.S.R.)

XI. LOGANBERRIES, BLACKBERRIES AND DEWBERRIES

(*Combined Pomological and Pathological Investigations.*)

43. Classification, Nomenclature and Variety Trials.

(*a*) Detailed records of the vigour and cropping of a collection of blackberries and dewberries are made each year and suitable parents for clonal races chosen from the most successful varieties. Many of the early flowering varieties suffered severely from frost damage, and the crop in 1938 was much less than that of 1937. Some of the late flowering varieties bore comparatively well, however. The mean crop per plant for the Parsley-leaved Berry was 10·5 lb., and for a broad-leaved variant of this variety 15 lb. The number of fruits per pound for both varieties was about normal, viz. 200. The amount of crop of Youngberries was light, but the size of the berries was again good. The average number of fruits per pound was about 100.

A number of new varieties including the Nectarberry, a thornless Loganberry and a thornless Boysenberry, were imported from America in the spring of 1938. The plants have been kept under observation in quarantine for a year, and, as they appear to be healthy, will be planted out and their performance compared with that of standard varieties.

(*b*) The amount and quality of the crop of a number of rogue plants received as "Loganberry" varied considerably. The heaviest cropping type yielded 6·5 lb., and the poorest 0·3 lb., per plant; thus the best yielded less than the true loganberry which gave 7 lb. per plant at the same distance of planting, viz. 7 feet × 6 feet.

(*c*) Six seedling blackberry varieties, raised by Mr. M. B. Crane of the John Innes Horticultural Institution, bore from 8 to 11 lb. of fruit per plant in 1938. The fruit varied in size from 170 to 200 berries per pound. The first picking of the earliest variety was on August 11th, and the latest continued to fruit until 7th October.

(*d*) A trial of 450 Loganberries and Phenomenal Berries planted in March, 1935, again bore a good crop in spite of considerable damage to the blossom. Although 35 per cent. of the Loganberry blossoms were found to be frosted, the crop was only 4 per cent. less in weight than in the previous year. This is partly accounted for by slightly larger fruit this year, but is most probably chiefly owing to the abnormally good setting of the later blossoms. Although the first Loganberry flowers opened ten days earlier in 1938 than in 1937, there was only a difference of one day in the time of the first picking of fruit, and cropping actually continued seven days longer in 1938 than in 1937. Thirty per cent. of the blossoms of the Phenomenal Berry, which flowers a few days later than the Loganberry, were killed by frost. The crop of this variety was 5 per cent. less than in 1937.

At 12 feet by 7 feet, the Loganberries bore an average crop of 11·5 lb. per plant (2·5 tons per acre) and the Phenomenal Berries 8 lb. per plant (1·7 tons per acre). The size of the Phenomenal Berry fruit was much greater, however, than that of the Loganberry, the mean number of Phenomenal Berries to the pound being 89 and of Loganberries 113.

The Phenomenal Berries were much less vigorous than the Loganberries for two years after planting, but equalled them in vigour during the third year (1937); in 1938 measurements of the length of the new cane again showed no difference between the two varieties.

(*e*) The fruiting cane of a number of clonal plants raised from two parents received as Himalaya and Black Diamond, wilted when in full bearing in August, 1938, and finally died. A similar trouble was recorded in 1937, when the fruiting cane of about 10 per cent. of each variety died. The young cane was not affected. The plants themselves and the soil in which they are growing have been carefully examined, but no reason for this trouble has yet been found. Further observations are being made. (A.B.B.)

53. Propagation.

During the year extensive trials were carried out to test the propagation by "leaf-bud" cuttings of the varieties Loganberry, Parsley-leaved Berry and Youngberry (both thorned and thornless forms). A detailed account has been published and is reprinted on page 218 of this report, giving an account of the technique employed and the results obtained together with a description of a practical means of raising plants in quantity by this method. (R.J.G. and D.H.H.)

58. Training.

Considerable differences in vigour and cropping were observed between Loganberry and Phenomenal Berry plants subjected to four training treatments. The two varieties reacted in the same way to any one treatment. The training methods were chosen primarily with a view to obtaining a measure of control of the Cane Spot disease *Elsinoë veneta* (see 77B. below). This disease can be distributed by spores carried in water, and, if the young cane is trained below the fruiting cane, it becomes infected during the summer, as described below. Hence, all the training methods were designed to obviate this.

The fruiting cane was trained :—

(i) by weaving.

(ii) in one direction on single wirework.

(iii) in one direction on double wirework.

(iv) as a fan.

In (i) and (iv) the young cane was trained first vertically and then above the fruiting cane, and in (ii) and (iii) it was tied to one side of the plant, the fruiting cane being on the other. In methods (i) and (ii) the plants are at 12 feet and in (iii) and (iv) at 6 feet apart in the rows. The rows are always 7 feet apart.

The highest yield for Loganberries was 11·5 lb. per plant (2·5 tons per acre), obtained with method (i). With method (ii) the average yield was 10 lb. per plant (2·2 tons per acre), and, with each of (iii) and (iv), 7 lb. per plant. As plants trained by methods (iii) and (iv) are at 6 feet apart in the rows, however, the yield per acre was higher than with methods (i) and (ii) viz. 3 tons per acre. As will be seen below (77B.), the more crowded plants at 6 feet are subject to the greater risk of Cane Spot infection, and for them spraying is therefore likely to be more necessary than for the more widely spaced plants.

Similar differences in cropping were shown by the Phenomenal Berries but the mean crop was 25 per cent. below that for Loganberries. (A.B.B.)

77B. Cane Spot.

Work on the control of this disease, caused by the fungus *Elsinoë veneta*, is carried out in collaboration with the Mycology Section and with the Insecticides and Fungicides Section.

Loganberry and Phenomenal Berry, while responding in the same way to attempts to control the disease by modified training methods or by spraying, yet show great differences in varietal susceptibility to this disease, the Phenomenal Berry being consistently less severely affected than the Loganberry.

Infection on plants trained by methods (i) and (ii) (see 58 above), at 12 feet apart in the rows, was less severe than on those trained by methods (iii) and (iv), at 6 feet apart. The crowding of the canes in the more closely planted plots appears to have had considerable bearing on the incidence of the disease. There was, however, no difference in the degree of infection between methods (i) and (ii) or between (iii) and (iv).

Since complete control was not obtained by modified training treatments alone, the further effect of copper sprays applied at various periods during the summer is also being studied. A reduction in the amount of Cane Spot, though not a complete control, was observed on three-year-old Loganberry and Phenomenal Berry plants in 1937 where a colloidal copper spray was applied in June. In 1938, therefore, two applications were compared with one, but general infection on the plants in this trial proved to be much less severe than in 1937. With plants at 6 feet apart (see 58 above), infection on the fruiting laterals of Loganberries sprayed in May and June was lighter than on those sprayed in June only. Infection on plants at 12 feet apart was only very slight and on these, therefore, the addition of the earlier spray showed no improvement in control.

Loganberries were planted on another plot in spring, 1938, to determine whether Cane Spot control can be improved by applying a fungicide at the post-cropping period as well as, or instead of, in May and June. Two training treatments will be employed, the young cane being above the fruiting cane in one and below in the other.

(A.B.B., R.V.H and M.H.M.)

86A. Blackberry Mites.

There are indications that the " Red Berry " disease of blackberries is less prevalent following a tar wash. Investigations are now in progress to determine the effect of spraying with various concentrations of a tar distillate wash in relation to the " Red Berry " disease. According to American workers, a mite is responsible for this condition of the fruits. (A.M.M. and G.H.L.D.)

86B. The Insect and Allied Fauna of Rubus.

See under VI Entomology, 86B.

104. Virus Diseases of Blackberry and Loganberry.

In 1937 the cane inarching method was used for studying the transmission of the virus diseases " Reversion " (or Dwarf) of Phenomenal Berry and Blackberry, and Mosaic of Blackberry to Phenomenal Berry, Loganberry, Blackberry and Raspberry. The plants are being kept under observation and symptoms noted. (R.V.H.)

105. Non-parasitic Disorders.

A trouble has been observed in Loganberries and Blackberries in recent years, similar in appearance and effect to the " die-back " or " dwarf lateral scorch " of Raspberries which has been found to be correlated with mild mean temperatures in the

preceding winters. Comparable series of one-year-old Loganberries in pots were, therefore, placed in cold storage chambers at (1) 32° F. and (2) 45° F. in December, 1937, for three months. When the plants were removed from the store they were kept under observation in a cold greenhouse. The plants which had been kept at 32° F. grew normally while those kept at 45° F. developed poorly and much of the cane died back. The symptoms were similar in appearance to those observed in the field. Forty-five per cent. of the cane of the plants kept at the higher temperature died during the spring, whereas only 4 per cent. of the cane of those kept at 32° F. died. The treatments were repeated, using the same plants, in December, 1938, and the results will be observed in 1939.

In extension of this work sets of one-year-old plants of Phenomenal Berry and Himalaya Berry were placed in chambers at 31° F. and 40° F. in December, 1938. They will be removed after three months and placed in a cold greenhouse.

(R.V.H. and A.B.B.)

Section III

PRELIMINARY RESEARCH REPORTS

POMOLOGY

PEAR ROOTSTOCKS FROM SEED

I. EXPERIMENTS ON METHODS OF GERMINATING PEAR SEEDS

By H. M. TYDEMAN

All the work so far done on seedling rootstocks for pears has shown quite conclusively that they vary widely not only in their vegetative characters but also in their influence on the vigour and fruitfulness of the scion variety. Such stocks may be completely incompatible with the scion, or trees on them may show varying degrees of vigour. Although representative selections of free pear rootstocks have been reproduced by vegetative means, no method has yet been found for raising them in quantity for commercial purposes. While it is true that free pear rootstocks are not used extensively in this country they are employed in considerable quantities abroad. In England their principal use is with such varieties as Williams's Bon Chrétien, which are incompatible with the established varieties of quince, or those which make only dwarf trees on quince. It has frequently been observed that individual trees in orchards of pear worked on seedling rootstocks show great variability both in size and cropping.

In view of these facts it was decided to ascertain what variability, with respect to their morphological characters, was shown by seedlings raised from seed collected from different sources, and to what extent uniformity of performance was to be expected in such populations. Although it is occasionally claimed that there are varieties of apples and pears which will breed true, it is extremely doubtful if such true breeding varieties really exist, and a certain measure of variability is probable in such fruits after sexual propagation.

At East Malling are fruiting trees of the East Malling Clonal Free Pear rootstocks and it was decided to see how far seedlings raised from seed from these trees came true to the parental type and what degree of uniformity would be shown by families of seedlings from known mother trees. Later, it is hoped to extend this study to an investigation of the inheritance of characters in the progeny from controlled crosses between varieties of pear rootstocks.

Since much difficulty was experienced in germinating pear seeds, particularly in South Africa, where serious losses had been sustained through this cause in commercial practice, investigations were carried out at the same time to determine the causes of these failures and the factors influencing seed germination in pears. It was arranged, concurrently, to supply to the Department of Agriculture and Forestry, Pretoria, South Africa, samples of pear seed from the East Malling mother trees treated in various ways

in order that a comparison of their germination might be made under English and South African conditions. While the results obtained in South Africa in 1938 were in complete agreement with those obtained both in 1937 and 1938 at East Malling, the results obtained in South Africa in 1937 were in certain respects apparently contradictory. At the moment, this is thought to have been due to some accidental difference in the conditions to which the seeds were subjected in that year during their journey to South Africa or after their arrival. Until it has been possible to go into the question carefully with the workers concerned in South Africa, a full explanation of the possibly anomalous results obtained in that year will not be possible.

The work began at East Malling in the autumn of 1936. It was decided, in the first place, to ascertain the best method of storing the seed prior to germination and the best conditions for germination once the seed was sown.

Experiments at East Malling 1936-8.

Fruits were obtained from a tree of pear selection A1 on 11th November, 1936, and they were divided into five batches and treated as follows :

(*a*) The seeds were taken from the fruits and sown immediately. Seeds of selection C2 were also sown in order to see whether there were varietal differences in germination capacity.

(*b*) The fruits were placed in an earthen clamp or pit in the open ground and covered with straw and earth to a depth of a few inches. Samples of seed were taken from the fruits and sown on 18th February, 1937, and again on 14th June, 1937.

(*c*) The seeds were dried and stored in paper bags in a room at a temperature around about 20° C. Samples were sown on 18th February, 1937 and again on 14th June, 1937.

(*d*) Fruits were placed in a cold chamber at the Ditton Laboratory at a temperature of 0° C. Seeds were removed from these fruits and sown on 14th June, 1937.

(*e*) The seeds were placed in dry sand in flower pots out of doors.

The seeds were sown in a light sandy loam in shallow wooden boxes. Three samples of seed were sown from each treatment. One was placed in a warm greenhouse kept throughout at a temperature well above that in the open. Another was placed in an unheated greenhouse, and the third out of doors fully exposed to the weather.

Where the seeds were taken from the fruits in the late autumn and sown immediately they started to germinate by the middle of February, as is shown in Table I. The seeds in the cold greenhouse germinated in greater quantity during the earlier stages, but were quickly caught up by those growing in the open. From the outset, the germination of the seeds in the heated greenhouse was poorer and by the end of May, little more than a quarter of these seeds had germinated. There seemed to be little difference in the germination capacity of the seeds of A1 and C2.

In Table II is shown the germination of seeds taken from fruits stored through the winter in a clamp in the open. In general, the germination of these seeds was better than that of the seeds sown in the autumn. Once again, the germination of the seeds in the heated greenhouse was markedly poorer than the others, although nearly double that of seeds sown in the autumn and placed in the same house. This suggests that the partial overwintering out of doors, while it unquestionably improved germination, did not entirely counteract the bad effect of too high a temperature during the germination period. It will be noticed that the seeds in the warm greenhouse started to germinate

TABLE I. GERMINATION OF SEEDS TAKEN FROM THE FRUIT AND SOWN 11TH NOVEMBER, 1936.

Clonal Selection.	Treatment of sown seed.	Number of seeds sown.	Percentage germination.							
			18/2/37	5/3/37	20/3/37	3/4/37	16/4/37	30/4/37	14/5/37	28/5/37
A1	Heated greenhouse	100	4	15	21	24	24	25	26	26
A1	Cold greenhouse	100	10	39	62	77	77	77	77	77
A1	Out of doors	100	3	20	30	42	58	66	73	74
C2	Heated greenhouse	100	5	16	21	27	27	27	28	28
C2	Cold greenhouse	100	33	68	72	80	80	80	80	80
C2	Out of doors	100	7	49	69	80	86	86	86	86

earlier and only later fell behind the other batches. The seeds in the cold greenhouse germinated much more rapidly than those placed out of doors ; the latter did not germinate in any quantity until conditions became warmer towards the end of April.

TABLE II. GERMINATION OF SEEDS TAKEN FROM FRUITS WHICH HAD BEEN STORED IN AN EARTHEN CLAMP IN THE OPEN FROM EARLY NOVEMBER. SEEDS EXTRACTED FROM THE FRUITS AND SOWN, 18th FEBRUARY, 1937.

Clonal Selection.	Treatment of sown seed.	Number of seeds sown.	Percentage germination.						
			4/3/37	20/3/37	3/4/37	16/4/37	30/4/37	14/5/37	28/5/37
A1	Heated greenhouse	40	8	40	48	48	48	48	50
A1	Cold greenhouse	40	0	25	90	95	95	95	95
A1	Out of doors	40	0	0	5	70	85	86	86

The seeds taken from the fruits and stored during the greater part of the winter in a warm room germinated much more poorly than those of either of the other treatments, as can be seen from Table III. Where they were placed in the warm greenhouse they failed to germinate altogether, and where they were placed out of doors less than half the seeds had germinated by the end of the following May. Although the boxes were saved until well into the following spring no further seedlings were obtained.

TABLE III. GERMINATION OF SEEDS TAKEN FROM THE FRUITS ON 11TH NOVEMBER, 1936, DRIED AND STORED IN PAPER BAGS IN A WARM ROOM. SEEDS SOWN 18TH FEBRUARY, 1937.

Clonal Selection.	Treatment of sown seed.	Number of seeds sown.	Percentage germination.					
			2/4/37	12/4/37	16/4/37	30/4/37	14/5/37	28/5/37
A1	Heated greenhouse	100	0	0	0	0	0	0
A1	Cold greenhouse	100	2	2	11	11	11	11
A1	Out of doors	100	0	3	9	36	43	49

It seems fairly clear that the warm, dry conditions under which these seeds were kept from November until February prevented them from germinating satisfactorily during 1937, although as will be seen from Table IV, they germinated relatively quite well after exposure to cold conditions during the winter of 1937-8.

The fruits kept in cold store in the Ditton Laboratory were taken out in the middle of June. Samples of seed were taken from them and sown at once, together with seed from fruits stored in the clamp and seed kept since the previous November in a warm room. They were all placed in the unheated greenhouse. In Table IV is shown the germination of these three batches of seeds. None of them started to germinate before the following February and germination was not, on the whole, particularly good. The seeds from the cold chamber germinated the best, although those stored at room temperature were almost equally good. It will be noted that these latter seeds had been subjected to a period of cold during the winter of 1937-8 and this accounts for their relatively good germination. Seeds from the fruits stored in the clamp failed almost completely.

Table IV. Germination of Seeds Cold Stored, Clamped and Dried, Sown on 14th June, 1937, and Kept in the Unheated Greenhouse.

Clonal selection.	Winter treatment. (Before sowing.)	Number of seeds sown.	Percentage germination.					
			6/2/38	20/2/38	7/3/38	21/4/38	28/4/38	31/5/38
A1	Cold stored	50	8	34	54	64	64	64
A1	Clamped	50	0	0	0	4	4	4
A1	Dried and stored in bags	50	12	12	12	58	58	58

No explanation can be offered at present, as to why the seeds from the fruits overwintered in the clamp germinated so poorly in comparison with the rest. The possibility that the seeds may have decayed in the fruits before sowing appears to be ruled out, since seeds similarly treated, sent to South Africa and sown there in July, germinated fairly well.

The foregoing experiments indicate that pear seeds require to be kept for a short period prior to germination at a low temperature, although there is no reason to think that this period need necessarily be during the winter. It does not appear to matter greatly whether the seeds are removed from the fruits in the autumn and sown directly out of doors or in a cold greenhouse or whether the fruits themselves are overwintered in an earthen clamp or cold store.

Stratification of seeds in dry sand out of doors may possibly be an efficient method if managed with care, but when it was tried here, during the winter of 1936-7, many of the seeds began to germinate in the sand early in the spring. The porous pots in which they had been placed had absorbed moisture from the surrounding air and this had started the seeds into growth. If the seeds can be kept quite dry and sown early before warm conditions commence in the spring it might prove quite efficient.

Since the time of sowing appeared to be so important for successful germination, a series of experiments was carried out at East Malling during 1937-8, to determine the best time to sow under our conditions. Successive sowings were made at intervals from October, 1937, until July, 1938. The variety used was B1, because it was available in largest quantity in this year and the seeds were sown in shallow drills in the open ground, wire frames being used to protect the seeds from birds. The seeds used had been treated in the three following ways.

(*a*) The seeds were taken from the fruits on 16th October, 1937, dried and stored in paper bags in a room at an average temperature of about 20° C., throughout the winter.

(*b*) The fruits were stored in a cold chamber at the Ditton Laboratory at a temperature of 0° C. Seeds were extracted from the fruits on the day of sowing.

(*c*) The fruits were stored in an earthen clamp or pit in the open ground. Seeds were extracted from the fruits on the day of sowing.

The results of these experiments are shown in Table V. Taking the results as a whole, germination was poor. This can hardly have been due to the variety of seed used

TABLE V. GERMINATION OF SEEDS IN AN EXPERIMENT ON THE TIME OF SOWING AND OVERWINTER TREATMENT OF SEEDS. PEAR SELECTION B1.

Date of sowing.	Overwinter Treatment.	Number of seeds sown.	Percentage germination.							
			3/3/38	16/4/38	29/4/38	9/5/38	31/5/38	25/6/38	17/7/38	29/8/38
16/10/37	Sown direct from fruits	100	1	13	18	18	18	18	18	18
12/11/37	Warm room	100	0	5	7	7	7	7	7	7
12/11/37	Cold store	100	0	15	15	15	15	15	15	15
12/11/37	Earth clamp	100	0	7	9	9	12	12	12	12
22/12/37	Warm room	100	0	8	12	12	12	12	12	12
22/12/37	Cold store	100	1	15	16	16	16	16	16	16
22/12/37	Earth clamp	100	0	11	14	18	18	18	18	18
16/1/38	Warm room	100	0	0	1	1	3	3	3	3
16/1/37	Cold store	100	0	14	17	17	17	17	17	17
16/1/38	Earth clamp	100	0	17	17	17	17	17	17	17
20/2/38	Warm room	100	0	0	0	0	0	1	1	1
20/2/38	Cold store	100	0	13	13	13	13	13	13	13
20/2/38	Earth clamp	100	0	25	26	26	26	26	26	26
17/3/38	Warm room	100	—	0	0	0	0	0	0	0
17/3/38	Cold store	100	—	26	30	30	30	30	30	30
17/3/38	Earth clamp	100	—	10	20	20	20	20	20	20
22/4/38	Warm room	100	—	—	0	0	0	0	0	0
22/4/38	Cold store	100	—	—	0	0	28	28	28	28
22/4/38	Earth clamp	100	—	—	0	0	26	26	26	26
31/5/38	Warm room	100	—	—	—	—	—	0	0	0
31/5/38	Cold store	100	—	—	—	—	—	3	3	3
31/5/38	Earth clamp	100	—	—	—	—	—	0	0	0
18/7/38	Warm room	100	—	—	—	—	—	—	—	0
18/7/38	Cold store	100	—	—	—	—	—	—	—	0
18/7/38	Earth clamp	100	—	—	—	—	—	—	—	0

since similar seed gave good results in South Africa in the same year. It was more probable that the dry, cold weather experienced at East Malling during that spring was not favourable for good germination. It is interesting, however, that the seeds overwintered in the warm room again gave the poorest results. Only where this seed was sown *before* the severest part of the winter did any quantity germinate. This is additional strong evidence of the importance for germination of subjecting such seed to a period of cold. As in 1936-7 there seemed little to choose between the seeds from the cold stored fruits and the fruits stored in the clamp. Both germinated fairly rapidly during April. The best germination occurred when the seeds were sown during February or March, suggesting that this is the best time to sow under East Malling conditions. Where sowing was left as late as the end of May the result was extremely disappointing.

Very striking results were obtained in 1938 as a result of washing pear seeds in water prior to sowing. In the autumn of 1937, Mr. P. Bick, while staying at East Malling

took seeds direct from the fruits of pear selection C2 which had just been picked from the tree and washed them in plain water. They were sown immediately together with unwashed seed also taken straight from the fruit. They began to germinate in the spring of the following year. Of nearly seven hundred washed seeds sown, 50·2 per cent. had germinated by the following autumn and the seedlings averaged 25·7 cm. in height. Of the unwashed seeds, only 30·3 per cent. had germinated and the seedlings averaged 13·6 cm. in height. The greater height of the seedlings from the washed seed was due to their much earlier germination. It seems that the removal of the mucilaginous film to be seen covering the seeds of apples and pears when they are first taken from the fruit may definitely accelerate and improve their germination provided the seeds are sown immediately and not allowed to dry.

These experiments, as far as they go, seem to point to certain definite conclusions. Pear seeds appear to require a short dormant period under cold conditions if they are to germinate satisfactorily. It seems that this period need not be unduly prolonged, since seeds taken from the fruits in November and sown in February, after exposure to cold, have germinated quite well. On the other hand, seeds overwintered under warm conditions, either dry in packets in a warm room, or kept moist in the seed boxes in a warm greenhouse, have never germinated well. It is possible, too, that germination may be impaired if the seeds are subjected to a second cold period separated from the first by a spell of warmer conditions.

Time of sowing appears to be an important consideration. Seed sown in the late autumn germinated satisfactorily when it was kept cold throughout the winter, but seeds overwintered in the fruit under cold conditions and sown from late February to mid April gave better results. Left as late as June or July, such seeds failed to germinate at all during that year, but germinated somewhat poorly during the following spring.

So far as variety of seed is concerned, there is no evidence at present of any large and consistent differences in the natural viability of the seeds from different selections. At East Malling it was only possible to try three fairly representative types but more were tried in South Africa. While there were considerable differences in the germination of the various batches, there is no reason to suppose that this was in any way related to the variety of seed employed.

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The work described in this paper was carried out in collaboration with the Department of Agriculture and Forestry, Pretoria, South Africa. The writer is deeply indebted to Mr. H. B. Terry of that Department, who kindly furnished the fullest particulars of germination tests made in South Africa. He also wishes to thank Dr. C. West, Superintendent of the Ditton Laboratory who several times placed facilities for the cold storage of seeds at his disposal. During his short visit to East Malling, Mr. P. Bick took the greatest interest in this work and his wide knowledge of South African conditions was of the greatest assistance to the writer; his collaboration is gratefully acknowledged. Finally, the writer's warmest thanks are due to Mr. Arthur Tidy, upon whose shoulders the greater part of the practical work in connection with the conduct of these experiments inevitably fell.

Summary.

Experiments were carried out in collaboration with the Department of Agriculture and Forestry, Union of South Africa to discover whether seed from the East Malling selected clonal free pear rootstocks would germinate better under South African conditions

than varieties of pear seeds already being used there, and the best methods of germinating such seeds.

At East Malling, when seeds were taken straight from the fruits in the autumn and sown in shallow boxes placed in (*a*) a warm greenhouse, (*b*) an unheated greenhouse and (*c*) the open ground, those seeds treated as *b* and *c* germinated much better than those treated as *a*.

Where fruits were kept in an earth clamp or pit out of doors from early November until mid February and then sown as *a*, *b* and *c*, germination was, on the whole, better than where the seeds were sown direct from the fruits in early November, but seeds treated as *b* and *c* again germinated much better than those treated as *a*.

When seeds were taken from the ripe fruits in the late autumn, stored in paper bags in a warm room until 18th February, and then sown as in *a*, *b* and *c*, germination was generally poor but the seeds kept in the open ground germinated much better than the others.

Seeds overwintered since the previous November in a warm room, in an earth clamp or pit and in a cold chamber at 0° C. and sown in the middle of June, failed to germinate that year. In the following spring the seeds stored in the earth clamp failed almost completely, but those stored in the warm room and in the cold chamber germinated fairly well.

Seeds stored (1) out of the fruits in a warm room, (2) in the fruits in an earth clamp and (3) in the fruits in a cold chamber, were sown at intervals from mid October to mid July. They germinated best when sown in February, March or April, although seeds sown in April were much later in germinating than those sown earlier. Where the seeds had been overwintered in a warm room, germination was usually poor, but the seeds kept cold throughout the winter germinated much better.

These results emphasize the importance of overwintering pear seeds under cold conditions. The best results are to be expected where the seeds are given a single, short cold period, either while they are still within the fruit or in the seed boxes. When they are stored within the fruits the seeds should be taken out and sown in the early spring.

PEAR ROOTSTOCKS FROM SEED

II. STUDIES ON THE VARIATION IN SEEDLING PEAR TREES

By H. M. TYDEMAN

The raiser of seedling rootstocks for apples or pears has to take into account the great inherent variability of the material with which he is dealing. Since the chief source of seed for pear rootstocks is in the wastage from perry or similar processing factories, an important factor making for variability is the variety of pollen, which is usually unknown. With many varieties of pears, fertilization by pollen from another variety is necessary if fruits are to set, and where self-fertilization takes place the seed content of the fruits is usually greatly reduced. Since pollen of another variety will usually bring with it factors for a completely fresh set of characters, it forms an inexhaustible source of variation.

Although the nurseryman is primarily concerned only with the vigour of seedling pear rootstocks, and is not immediately interested in their botanical resemblances or differences, such characters as leaf shape or wood colour might conceivably form useful clues in predicting the subsequent behaviour of the seedlings as rootstocks. For instance the East Malling Clonal Free Pear rootstocks show remarkable divergence with respect to their botanical characters, and equally wide differences in their behaviour when worked with pear varieties. It is of more than academic interest to study how far these morphological characters breed out in the seedlings from certain known mother plants, whether any are sufficiently consistent to make a definite system of grading practicable, and whether such differences can be related in any way to the behaviour of the seedlings when used as rootstocks.

Observations have been made at this Station on pear seedlings from several sources. In particular, detailed records have been kept on :

1. Seedlings raised from the East Malling Free Pear Rootstocks.
2. Seedlings obtained from seeds collected in the natural fruit forests of the North Caucasus.

All were open pollinated, that is, the pollen parent is quite unknown and although, for that reason, studies of their characters are of little genetic interest, they may serve as an illustration of the variability to be expected in chance populations of pear seedlings. The botanical descriptions of these seedlings were made when they were of approximately the same age.

Seedlings from East Malling Free Pear Rootstock A1.

The tree from which these seeds were obtained was growing on a small plot containing trees of numerous other types of free pear. It is fairly safe to assume that a large amount of cross pollination took place and the seedlings to be described may have any one of a large number of pear rootstock varieties as pollen parent.

These seedlings were raised from seeds which germinated during the late spring of 1937. They were planted out during the late summer of 1937 and were described during the latter part of 1938.

(*a*) *Vigour.* By the middle of their second year from the seed, these seedlings varied in height from a few inches to nearly two feet. At this comparatively early stage some part of the variation may have been attributable to differences in the time at which they germinated but it was possible to pick out a small proportion of weakly growing individuals which were in all probability naturally dwarf growing, while a few were noticeably more vigorous growing than the rest. Most of the seedlings had long lateral growths and short sharp spines but these were absent from some quite vigorous seedlings.

(*b*) *Wood Colour.* The wood colour of the seed parent is reddish brown with much pubescence on the wood. Among the seedlings, the wood colour ranged from reddish brown to green, and in some of them the wood was noted as having no pubescence.

(*c*) *Lenticels.* The lenticels on the wood of these seedlings were extremely variable. They differed widely in number, size and shape.

(*d*) *Leaf Size and Shape.* The leaves were usually of medium size and mostly medium ovate to oval, like the seed parent. Seedlings were found, however, with almost round leaves and others with leaves much elongated and narrow.

(*e*) *Leaf Apex and Serrations.* The apex of the leaves varied considerably. Where the leaves were oval they tapered gradually to the tip which was slightly drawn out or acuminate. Where the leaves were broader they narrowed towards the apex more abruptly and the tips were more drawn out. The leaf margins were usually sharply serrate like the seed parent but numerous seedlings had leaves with marginal teeth which were rounded and obtusely toothed.

(*f*) *Leaf Surface and Pose.* The leaves of most of the seedlings were folded upwards along the midrib but on many plants the folding was very shallow or the leaves were quite flat. The leaves were often turned upwards on the petioles but frequently the leaves were horizontal and the tips were curved downwards. In a few seedlings the leaves were curved right over the petioles.

(*g*) *Leaf Colour and Hairiness.* The leaves were very variable in colour, which ranged from a light yellowish green to a dark green, and they were mostly devoid of hairs. Seedlings with woolly leaves characteristic of the Malling B type were not found.

(*h*) *Petiole Length and Colour.* There was every possible variation in petiole length and in most of the seedlings the petioles were tinged with red but in others they were quite green.

(*i*) *Leaf Stipules.* The stipules were small and lanceolate. In some instances they were serrately toothed but frequently the margins were entire. In some seedlings they were spread out on either side of the petioles, in others they were closely folded along the petioles.

Observations on seedlings of B1 and C2 showed that these families were quite as variable as that just described. Among the seedlings of C2 the leaves varied in shape and were not exclusively of the rounded type characteristic of that group, nor were seedlings with woolly leaves observed with great frequency among the progeny of B2.

Seedlings Raised from Seeds Collected from Selected Trees in North Caucasus.

These seeds were sent to East Malling in the spring of 1931 through the Division of Pomology, Academy of Applied Sciences, Leningrad, U.S.S.R. There were six selections each collected from a different tree in Teberda, North Caucasus. Since they had been derived from trees in large wild populations, growing under natural conditions, it was thought that they might show less variability with respect to their morphological characters than seedlings from trees growing in cultivated orchards where the opportunities for intercrossing with varieties of very diverse types might be presumed to be very much greater. It seemed possible that such material might prove very suitable for use as seedling rootstocks since constant inbreeding would have been likely to have segregated out the weak types which would have perished under the rigorous conditions in which they were growing. In this way it is possible to see how races might have been evolved, uniformly vigorous and hardy, and capable of producing offspring showing little variation from the parental characters. These seedlings have been under observation for six years and the following is a brief description of their principal characteristics.

(*a*) *Vigour.* At the end of their first season these seedlings showed great variation in vigour. They varied in height from 3 to 28 inches. Later, they evened up to a very large extent and, at the end of their sixth year, most of them were quite vigorous. They had reached a height of from six to eight feet and were usually fairly erect growing with many crowded laterals armed with sharp spines. It should be emphasized that this tendency to " even up " as they grow older is a common characteristic of seedling trees.

(*b*) *Wood Colour.* The colour of the wood of the young seedlings varied from reddish brown to greenish brown, but on the older trees the young wood was invariably reddish brown. The wood was always slightly pubescent towards the upper part.

(*c*) *Lenticels.* There was great variation with respect to both number and size of lenticels among these seedlings. In many they were large and numerous but in others they were small, sparse and inconspicuous.

(*d*) *Bud Shape.* The dormant buds were usually plump and rounded in shape and deep red in colour. Numerous seedlings, however, had triangular buds, wide across the base and tapering towards a rounded apex. Such buds were somewhat flattened and closely adpressed to the shoots. The buds were usually small but occasionally they were comparatively large.

(*e*) *Leaf Size and Shape.* On the young seedlings the leaves were usually of medium size and somewhat narrowly oval, but some seedlings had broader leaves than others. On the older trees, the leaves varied greatly upon the same tree, as was to have been expected. The leaves were larger and broader on the vigorous terminal shoots than on the short laterals and spurs. Between comparable leaves on the different seedlings there can have been very little variation, however. When ten leaves from each of fifty different seedlings were measured, it was found that when the breadth was calculated as a percentage of the length, the coefficient of variability for the fifty individuals was only 4·27 per cent. So little variation might easily have been accounted for by chance fluctuations not due to genetical differences at all. The leaves of these seedlings were much narrower, on the whole, than leaves from trees of the East Malling selected free pears. They are, therefore, possibly, a distinct species.

(*f*) *Leaf Apex and Serrations.* The leaves usually tapered gradually towards the apex and the tips of the leaves were slightly drawn out and acuminate. Occasionally, where the leaves were somewhat broader, they tapered more sharply and the tips were

more drawn out. Where serrations were present on the leaf margins they were always small and acutely serrate. Frequently, however, there were no serrations and the leaf margins were entire.

(*g*) *Leaf Surface and Pose.* These two characters showed greater variation than any others that have been studied. In most plants the leaves on the young shoots were only slightly upfolded along the midrib, but many had flat leaves, and others leaves which were very deeply upfolded. Most of the seedlings had horizontal leaves but in many the tips of the leaves were curved downwards, giving the leaves a recurved appearance while, in others, the leaves drooped downwards on the petioles. The principal differences can be seen in Fig. 1.

(*h*) *Leaf Colour and Hairiness.* The leaves of these seedlings were dark, shiny green, rather paler and shiny underneath. They were quite devoid of hairs on both the upper and under surfaces.

(*i*) *Leaf Petiole: Length and Colour.* The leaf petioles were of medium length and about a quarter as long as the blade of the leaf. In order to ascertain the exact amount of variation which the seedlings were showing with respect to this character, ten leaves were measured from each of fifty seedlings. The coefficient of variability for the fifty individuals proved to be only 6·6 per cent. of the mean, suggesting that they were very uniform. All the petioles were tinged bright red with but little variation.

(*j*) *Leaf Stipules.* The stipules were usually long, narrow and held erect. Some were rather broader than others, and they were occasionally somewhat spreading.

The root systems of these seedlings were examined in detail at the end of their first year from the seed. There was, at that time, some variation in the type of root system found. In many a few coarse roots had grown vertically downwards, in others the roots were smaller but more numerous and frequently they had a more spreading tendency. There was little fibre on any of the root systems.

It has always been difficult to induce these seedlings to produce adventitious roots. Some of them have been grown, cut down as stools, for several years and although they send up numerous shoots each year, so far they have always rooted very poorly or not at all.

Although they have now been growing on their own roots at East Malling for about six years and have made vigorous growth, these seedlings have not yet produced any flowers or fruit. The growth is similar to that usually found in seedling trees during the so called "juvenile" period. The laterals and spur-like growths, upon which fruit is produced in mature trees, are usually thorny and covered with rosettes of small leaves.

Some variability has been found in all the families of pear seedlings studied here, Just how much of this is to be attributed to chance fluctuation due to causes outside the plant and how much arose from genetic differences within the seedlings themselves, is not easy to determine. Fluctuations within populations of plants of a single vegetative clone are often larger than might be supposed. This has been strikingly demonstrated with apples (3, 4). When allowance has been made for these, however, a great deal of the variation found in the seedlings of the East Malling selected free pear rootstocks must unquestionably have been of genetic origin. That it was so great was to have been expected since the seedlings arose from flowers which may have been pollinated by any one of a large number of distinct varieties. It is almost certain that such seedlings will show great variability not only with respect to their botanical characters but also, it may be presumed, in their capacity, when used as rootstocks, to influence the vigour and precocity of the scion variety.

The seedlings raised from seeds collected in the forests of North Caucasus were rather less variable. For two characters, leaf shape and the length of the leaf petioles, both of them subject to great variation in families of mixed genetic origin, the coefficient of variability was very low. After the first few years they were fairly even in vigour and showed little variation in many of their botanical characters. There were some differences in leaf pose and certain other characters, however.

These observations lend some support to the view that seedlings raised from trees growing in wild populations in which selection and inbreeding have been in operation through many generations are less variable than seedlings from trees growing under more cultivated conditions and subject to frequent cross fertilization by varieties of very different genetic constitution. It is clear that such trees do not breed even approximately true from seed under conditions of free inter-pollination. Among the hundred or so seedlings of Free Pear A1, it would have been difficult to pick out a single individual identical with the seed parent in all major respects, while seedlings resembling, in some one or other particular, quite divergent types could quite easily be found.

Researches by Kikuchi (2) and by Crane and Lewis, in their unpublished work mentioned by Crane and Lawrence (1) have shown that for certain characters such as the colour of the wood, hairiness of the wood, fruit and leaf colour, varieties of *Pyrus communis* and *Pyrus serotina*, have a very simple type of inheritance. Unlike the apple where variations has been found to be very great and no clear cut class intervals are usually observable, the pear varieties which have been studied show a mode of inheritance which can be explained on a very simple mendelian basis. For those characters which have been studied so far, the differences were discontinuous and clearly defined and in numerical proportions which accorded with expectation on the basis of the segregation and recombination of pairs of dominant or recessive factors.

Summary.

Details are given of observations made on seedling pears raised from open pollinated seed of East Malling selected Free Pear A1, and seedlings raised at East Malling from seeds collected from trees of wild pear growing in North Caucasus.

The variations found with respect to the vigour and habit of growth of the seedlings, the colour and hairiness of the wood, the number and size of the lenticels the shape, colour, hairiness and pose of the leaves, the length and colour of the leaf petioles and the size, shape and pose of the leaf stipules are described.

It is shown that the seedlings from East Malling Free Pear were, on the whole, more variable than the seedlings from the Caucasus and this is thought to be due to the greater opportunities for cross fertilization and out-breeding in trees growing under cultivated conditions.

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FIG. 1.

One year shoots of seedling pear from seeds collected in North Caucasus. Illustrating variation in vegetative shoots, particularly the pose and shape of the leaves.

STUDIES IN NURSERY TECHNIQUE

SHIELD-BUDDING—TREATMENT OF INSERTED BUDS WITH PETROLEUM JELLY

By R. J. GARNER and D. H. HAMMOND

In 1930 Staniland and Umpleby (4) reported upon trials carried out during the seasons 1926, 1927 and 1928 in order to discover a safe means of preventing the damage caused by the Red Bud Borer (*Thomasiniana oculiperda* Rubs.) to newly inserted buds. During the three seasons some four hundred buds of apples and roses were inserted into corresponding rootstocks. After preliminary trials in 1926, it was obvious that " vaseline " treatment of the buds was the best of five treatments tried. Following confirmatory trials in 1927 and 1928 the authors concluded that bud borer damage was prevented in the rose and the apple by coating the buds thoroughly, immediately after tying, with ordinary " vaseline ". They also found the " take " of buds to be unaffected, but they were not certain that this was increased by the treatment, though they remarked that callus formation was greatly stimulated by treatment with " vaseline ".

Trials at East Malling.

In May, 1938, the senior author (3) reported that buds of Cox's Orange Pippin, inserted into one hundred and sixty Malling No. II apple rootstocks in 1936, and treated with petroleum jelly, had given rise to one hundred and fifty maiden trees whereas a similar number, untreated, had only produced seventy-seven maiden trees. The Red Bud Borer was not seen during 1936 in the nurseries at East Malling and it was considered that the petroleum jelly may have had some beneficial effect, not connected with the prevention of bud borer damage, but it was pointed out that a further trial would be necessary to prove this.

In August, 1938, sixteen hundred Malling No. IX clonal rootstocks were available for this trial. These were divided into sixteen plots each containing one hundred rootstocks. All the rootstocks were shield-budded, the wood being left in the bud shield (2) in the ordinary way, with the variety Cox's Orange Pippin, and treated as follows : Half the buds were tied with rubber strips (1) and half with raffia ; half the rubber and half the raffia tied buds were immediately smeared with petroleum jelly ; the remainder were untreated.

The petroleum jelly, purchased locally at ninepence a pound, was smeared by means of the finger over the tied bud so that the bud and all cuts in the bark were completely covered.

One pound of the jelly was sufficient to treat more than eleven hundred buds.

The rubber strips employed were prepared from used motor-bicycle tubes by the nursery staff. They were very substantial strips and were not seriously affected by the application of the jelly. However, it is possible that the much thinner strips, specially manufactured for budding purposes, might be damaged by the jelly and thus prove unsatisfactory in combination with this treatment.

The rubber strips were fixed in position by means of a single half-hitch above the horizontal cut of the T incision. The raffia ties were completed with two half-hitches

in the same position. Any ties which broke or became loose during the first three weeks after budding were retied at once with new strips, or raffia, corresponding to the original material. Buds treated with jelly were smeared over, after retying, without further application.

On 4th March, 1939 the numbers of living and dead buds were recorded for each plot. The number of living buds was divided into those which had made a centimetre or more growth before the winter and those which had not. The figures obtained are given in the accompanying table. The outstanding result of the trial is the high performance of the buds treated with petroleum jelly, whether they were rubber or raffia tied. It will be noticed that in this trial the use of jelly has increased the take of buds some twenty-five per cent. over those not treated. The unusually low take of raffia-tied buds, not treated, is somewhat surprising and difficult to understand. It has been

Effect of Treatment with Petroleum Jelly of Rubber and Raffia tied buds of Cox's Orange Pippin budded upon Malling No. IX Rootstock in August, 1938.

State of Buds in March, 1939.

Treatment.	Live Buds. %	% Live Buds grown out in Autumn.
Tied with Rubber. Treated with Petroleum Jelly ..	99·0	17·7
Tied with Raffia. Treated with Petroleum Jelly ..	98·2	13·5
Tied with Rubber. Untreated	73·0	16·2
Tied with Raffia. Untreated	41·5	9·9
Tied with Rubber. Untreated. Adjacent Plot ..	87·5	15·7

suggested that the raffia, left around the buds during the winter, may have held an excessive amount of moisture thus causing the death of the buds. On the other hand, raffia may not have been so effective as rubber in sealing the buds against drying out and the entry of water during wet weather. This idea of the sealing effect of rubber appears to be supported by the fact that complete sealing of raffia and rubber with petroleum jelly resulted in similar excellent takes. As the raffia ties used in this trial were the only ones employed at East Malling during the 1938 budding season, it is impossible to check this result by comparision with other batches tied similarly.

However, it is interesting to note that in a trial carried out at East Malling in 1932 (1) ninety-two per cent. of rubber tied buds were successful compared with seventy-nine tied with raffia. The figure of seventy-three per cent. success with rubber tied untreated buds can be taken as an approximately normal figure, though it is somewhat low. In order to compare the performance of the buds in the trial with that of the buds in adjacent nursery rows a census of one thousand buds of the same variety and rootstock was taken on 6th March, 1939. Eight hundred and seventy-five of these buds were found to be alive, which is about eighty-seven per cent. Though this figure is fourteen per cent. better than rubber tied buds in the trials it is still eleven per cent. behind buds treated with jelly.

The proportion of successful buds which grow out before the winter following budding, may perhaps be taken as a measure of the "vigour" of the take. There is some slight evidence that more rubber than raffia tied buds grew out in the autumn, but the difference is not statistically significant. A close inspection of the dead buds failed to reveal any damage which might have been caused by insects. The authors are indebted to Dr. A. M. Massee for his valuable help in the inspection of the buds for traces of insect damage. In presenting these results the authors realized that the spring condition of buds is not always a sure indication of the number of trees which will be produced. However, judging by previous experience, apple buds recorded as alive in spring have, with very few exceptions, produced maiden trees. Rather than wait for the production of maidens it was thought that there might be some advantage in publishing these results before the 1939 budding season.

These results confirm those of Staniland and Umpleby, and show that treatment of buds with petroleum jelly, even when insect damage is not encountered, may have a favourable effect upon the take of buds and the stand of trees. The application of petroleum jelly to apple buds is so simple and inexpensive that its general use may well be undertaken by those who obtain unsatisfactory takes of buds.

Summary.

The work of Staniland and Umpleby of Long Ashton which showed that the treatment of newly inserted buds with petroleum jelly prevented damage by the Red Bud Borer (*Thomasiniana oculiperda*. Rubs.) is mentioned, and the results are given of a preliminary trial at East Malling in which the use of petroleum jelly on buds gave a fifty per cent. increase in the stand of trees.

Results of a trial involving sixteen hundred buddings are presented in detail and show a definite increase in bud-take following treatment with petroleum jelly in the absence of insect damage. Petroleum jelly treatment of newly inserted apple buds is recommended for trial wherever unsatisfactory takes occur.

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AN APPLE IRRIGATION TRIAL, USING SOIL MOISTURE METERS

By W. S. ROGERS

The maintenance of a suitable water supply is undoubtedly one of the main factors in plant growth. Even under our much maligned English summer conditions quite severe droughts sometimes occur, and artificial irrigation by the hose and sprinkler is regularly practised in some market gardens, private gardens and sports grounds.

The economic value of irrigation to the commercial grower depends mainly on the cost of the water application in relation to the improvement in crop, and enquiries received from growers who are using, or considering using, irrigation show that information on the best methods under English conditions is urgently needed. One of the main problems in economic irrigation is to know when to put the water on, and when to withold it. Observation of the top soil is not of great assistance, as the plant roots, at any rate in the case of tree and bush fruits, extend far below the surface.

What is needed, both by the grower and the experimenter, is an instrument that will indicate at a glance the soil moisture conditions at various depths. The present paper describes a simple irrigation trial in which such moisture recording instruments were used. It illustrates many of the drawbacks to which such trials are liable, and it shows the value and also the limitations of the moisture recorders used.

It is realized that the technique of experimental irrigation was far from ideal, as the apparatus had to be improvised. Nevertheless, since the interest in artificial irrigation in England is increasing, these results are worth putting forward, if only as a guide to a better technique in the future.

This trial followed a preliminary irrigation experiment carried out on apple trees at East Malling in 1932 by Amos, Hatton and Painter (2). In that experiment a single application of water, equivalent to 3 inches of rainfall, in June, was found to have no marked effect on weight, size or earliness of the crop. No moisture meters were then available and the only soil moisture records obtained were a few determinations made on soil samples, taken with an auger, before and after irrigation. It was decided to carry the investigation further when it became possible.

In June, 1934, a suitable opportunity seemed to have arrived, for the month of May was unusually hot and sunny, with a rainfall of only 0·71 inches. The material for making some new moisture meters of an improved pattern had just arrived, and it was accordingly decided to start a new irrigation experiment forthwith.

The Moisture Meters.

These instruments, originally developed in connection with our root development investigations, have already been fully described in other publications (5, 6, 7 and 8). They actually indicate the " suction force " of the soil, or " soil moisture tension ", which is due to the surface tension of the film of water surrounding the soil particles. This force varies with the moisture content of the soil. It is also affected by the degree of fineness and packing of the soil particles, hence to read actual moisture percentage in a given soil, calibration is necessary. The soil moisture tension itself is a more

useful figure to deal with, however, since it probably corresponds more nearly than any other figure at present available to the resistance of the soil to water intake by the plant.

The instrument measures the suction force by means of a thick-walled fine grained porous pot filled with water, buried in the soil at the required depth, and connected by a copper tube to a mercury manometer or vacuum gauge. When the soil is saturated the suction force is nil. As the soil dries the suction force rises, and water is drawn from the porous pot until the manometer balances the force. When the soil becomes re-wetted, water passes back into the pot with a corresponding fall of the mercury. The range of the instrument covers forces from 0 to about 60 cm. of mercury. Above this force the instrument merely remains at about 60 cm., showing that the force is 60 cm. or more. The soil suction at great degrees of dryness rises to many atmospheres, but the range covered by the meter appears to be of considerable use under cultivated crop conditions. Special devices used to prevent freezing in winter and errors due to air dissolved in the soil water are described elsewhere (5) with various other technical points.

Material.

The same trees were used as in the previous trial (2). These were twenty-year-old Early Victoria apples (on seedling Crab stocks) planted alternately at 14 feet with James Grieve (on Malling No. V). The former is marketed very early, and any increase in size is specially valuable. This material, although rather variable, had the advantage that individual tree records were available for many years back, and moreover the trees were adjacent to the main water supply. One row, containing eight trees of each variety, was irrigated, and a similar row 28 feet away was used as a control. A buffer row separated the two experimental rows.

Soil.

The soil was medium sandy loam to a depth of about 1 foot, followed by a rather lighter coloured sandy subsoil usually to between 30 inches and 36 inches. This lies on the porous Ragstone rock of the Hythe Beds. A dark sticky B horizon, or accumulation layer, pervious to water, occurs immediately above the rock. There was a gentle slope of 2·55 per cent. along the row. At saturation, the moisture content at a depth of 12 inches was about 35 per cent., at the field capacity about 18 per cent., and at the permanent wilting percentage about 6·8 per cent. Excavation studies on adjacent plots have shown that apple roots occupy the whole soil block from about 6 inches to the rock.

Location of irrigation furrows and moisture meters.

Six furrows about 4 inches deep were made, three on each side of the irrigated row, the first being 3 feet from the tree, and the other two 2 feet 6 inches and 5 feet respectively from the first, as shown in Fig. 1. For calculation purposes it was taken that the water would spread 3 feet from the outside furrows, making a total irrigated width of 22 feet. The row was 224 feet long, giving an area on which each 1,000 gallons of water was equivalent to a depth of 0·3906 inches.

Two moisture meters, B1 and B2, were installed on 9th June halfway down the irrigated row, in line with the tree trunks, and 4 feet from the 8th tree. The porous pots extended from 10 inches to 14 inches, and 28 inches to 32 inches, their centres being 12 inches and 30 inches deep, respectively. Two more meters, D1 and D2, were installed in comparable positions in the non-irrigated row on 11th June; and when

it was seen how slowly the water penetrated sideways, two more meters Z1 and Z2 were installed on 14th June, 18 inches from the tree row, and therefore also 18 inches from the nearest furrow, at depths of 12 inches and 30 inches, as shown in Fig. 1.

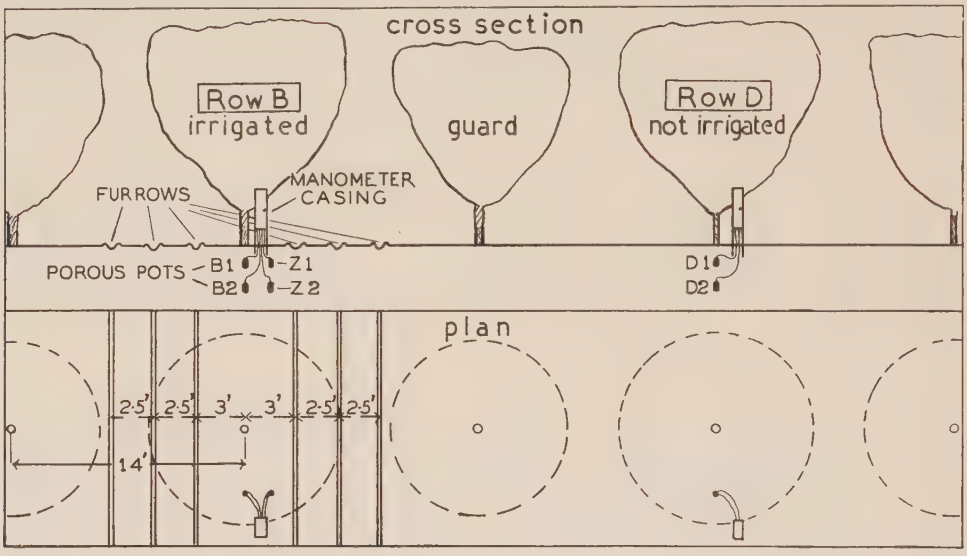

Fig. 1.
Location of irrigation furrows and moisture meters.

Application of water.

On 13th June irrigation was started. Water from six pipes, each controlled by a tap, was allowed to flow along the furrows at such a speed that by the time it reached the far end it just soaked in. The flow was adjusted from time to time, and was measured by taking the time required to fill a quart can. Irrigation was continued on 14th and 15th June. The details are given below :—

Date.	Hours' flow.	Gallons applied.	Equivalent inches
June 13	8	5,671	2·215
14	8	2,710	1·060
15	14½	4,857	1·897
Totals	30½	13,238	5·172

A month later, on 13th July, a further irrigation was given. This consisted of 9,582 gallons, or 3·744 inches, applied in 11 hours. Thus a total of 8·9 inches was applied in the two irrigations. The cost for Company's water, at 2s. 6d. per 1,000 gallons, was equivalent to about £2 17s. per inch per acre.

Results.

The effect of this 8·9 inches of extra water on the crop, though statistically significant, was comparatively small. It is proposed to give these results before discussing the soil moisture records, as the latter would appear to give the explanation.

Table I.

Early Victoria. Crop Records.

	1931.	1932.	1933.	1934.
Row B (7 trees) Irrigated 1932 and 1934.				
Total fruits (number)	3,119	8,994	2,106	10,052
Total fruits, weight, lb.	476	1,329	375	1,488
Average weight per fruit	0·153	0·148	0·178	0·148
Row D (7 trees) Non-Irrigated.				
Total fruits (number)	1,674	8,166	1,967	10,530
Total fruits, weight, lb.	243	1,202	386	1,405
Average weight per fruit	0·140	0·147	0·196	0·133

Table I shows the crop records of the irrigated and non-irrigated Early Victorias. These apples were picked on 31st July, 1934. The mean weight per apple is 0·148 lb. for the irrigated trees, and 0·133 for the non-irrigated trees, an increase of about 11 per cent. The number of apples on the irrigated row is smaller, but their total weight is greater than those on the non-irrigated row.

The percentage of the crop above $2\frac{1}{4}$ inch diameter, based on weight of fruit in the different size grades, was :—

Irrigated 56 per cent. Non-irrigated 37 per cent.

This difference is statistically significant. It is therefore seen that the irrigation has appreciably increased the size of fruit, causing both a greater amount and a bigger percentage of the fruit to come in the larger size grades.

Table II.

James Grieve. Crop Records.

	1931.	1932.	1933.	1934.
Row B (8 trees) Irrigated 1932 and 1934.				
Total fruits (number)	4,215	3,270	5,708	3,234
Total fruits, weight, lb.	632	643	881	687
Average weight per fruit	0·150	0·197	0·154	0·213
Bow D (8 trees) Non-Irrigated.				
Total fruits (number)	3,906	3,125	4,633	3,481
Total fruits, weight, lb.	580	624	728	656
Average weight per fruit	0·149	0·200	0·157	0·190

James Grieve is a later apple than Early Victoria. In 1934 its crop was picked in three pickings, from 29th August to 10th September. The crop records of the James Grieve, shown in Table II, give a rather more satisfactory comparison, for it will be noted that in 1931, 1932 and 1933 the average weight per fruit has been nearly the same on both rows. The weight of crop has been a little larger on Row B throughout. While no increase in fruit size followed the 3 inch irrigation in June, 1932, the 8·9 inch irrigation in 1934 was followed by an increase of average weight per fruit from 0·190

to 0·213 lb., again about 11 per cent. Statistical analysis shows this to be significant. Thus in both cases the size of fruit has been appreciably increased, though the increase in total crop weight was not great.

Soil Moisture Records.

The soil moisture records in Fig. 2 throw some light on the results given above. When the meters reached equilibrium after installation they showed a tension of about

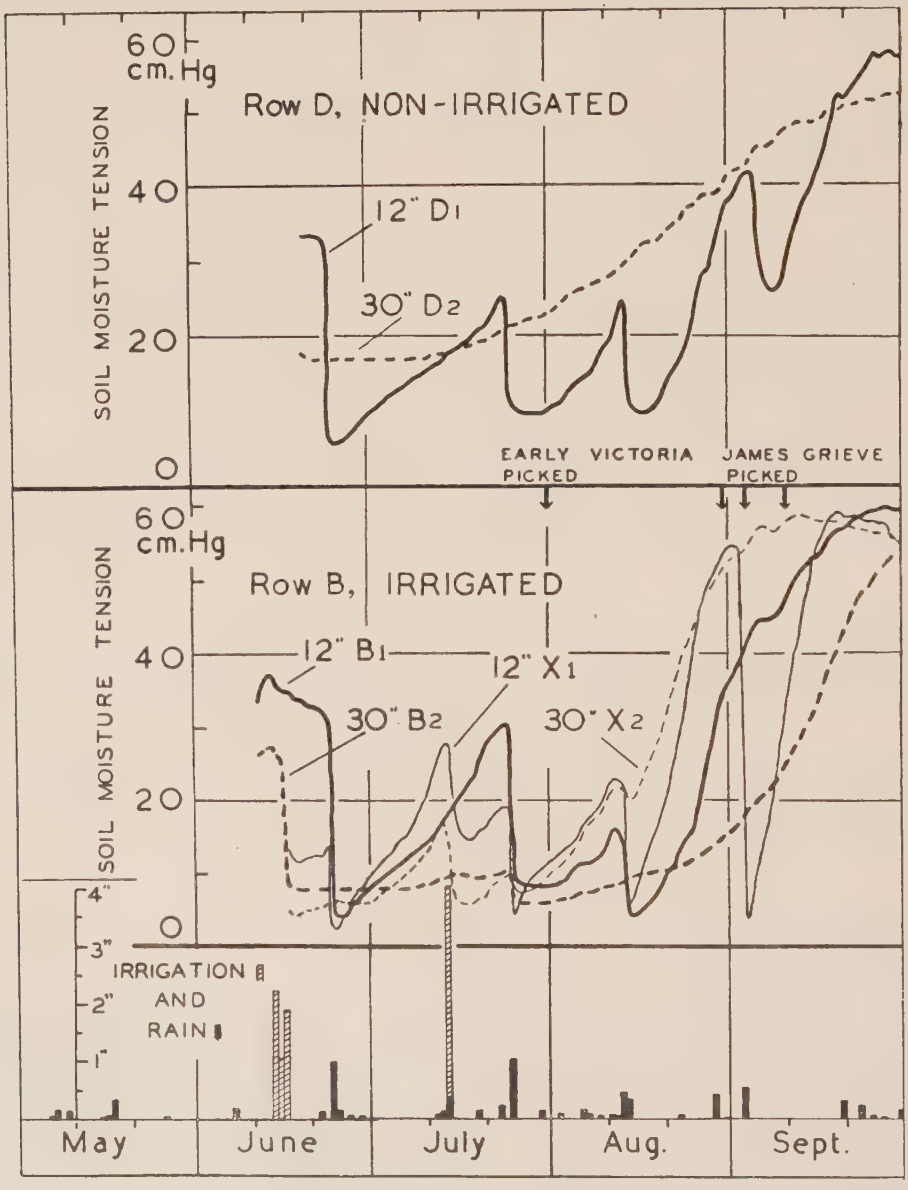

Fig. 2.

Soil moisture changes on irrigated and non-irrigated apple plots.

35 cm. Hg at 1 foot in both rows. All figures for meter readings that follow refer to centimetres of mercury. The higher the reading, the drier the soil. At the 30 inch depth in Row D (non-irrigated) the meter showed 18 cm., while the corresponding meter in Row B (to which water had not yet been applied) showed 28 cm. Therefore Row B was slightly drier to start with. This was confirmed by drying samples taken in quadruplicate, which showed the mean moisture percentage (on dry weight) at 30 inches to be 12·2 per cent. in Row B and 17·6 per cent. in Row D.

The irrigation as described above was begun on 13th June. The first surprise was that the meters B1 and B2 in the irrigated tree row fell only about 2 cm. in 36 hours after the application of water was started, showing that the water was only percolating very slowly sideways, and that the " water front " of saturation had not reached them (see Fig. 1). In the afternoon of 14th June the two extra meters Z1 and Z2 were installed 18 inches from the furrow. By the morning of 16th June meter Z2 showed 4·8 and meter B2 8·7 cm., showing the " water front " had reached beyond Z2 at 30 inches, and was just penetrating to B2. At the same time Z1 had fallen to 13·3, while B1 remained at 34·9. It was clear therefore that sideways penetration had been slower than downward penetration, and that the application of 3·27 inches of water during two days had not saturated the whole soil block. Irrigation was therefore continued for another day, during which 1·90 inches more water was applied. This further depressed meters Z1, Z2 and B2, but B1 only fell 1 cm. Fig. 2 shows that for the next six days the soil block was gradually coming towards equilibrium. Meter B2 remained constant at about 7·7 (which is found to be about the usual value for the " field capacity " in this soil). Apparently the roots used the moisture at 30 inches just as fast as it flowed from the soil at Z2, which gradually dried. Z1 rose and B1 fell, showing a gradual equalizing flow at 1 foot also. A shower on 21st June was followed, unfortunately for the experiment, by a deluge of 1·0 inch on 23rd June. This, of course, fell on the non-irrigated plot as well as on the irrigated plot, and brought down with a rush the tension shown by all the 1 foot meters, including the 1 foot meter on Row D (non-irrigated). The only 30 inch meter to show any response was Z2, which, being below soil already very wet, fell slightly. Drying conditions set in again, with such rapid water losses from evaporation and plant transpiration that rainfalls up to 0·15 inch did not cause the tension at 1 foot to fall.

On 13th July the second irrigation was carried out. 3·74 inches of water were applied, and there was also a rainfall of 0·32 inches, making a total of 4·06 inches. Again the water did not reach meter B1, 3 feet from the furrow, and the soil moisture tension in this position continued to rise. Meter Z1, only 18 inches from the furrow, fell during the following day, 14th July, and so did Z2, at a depth of 30 inches. B2, at 30 inches in the tree row, showed a slight fall in the succeeding 3 days, as the water gradually percolated towards it. All the meters were rising again after 18th July, but another 1 inch rainfall occurred on 24th July, and brought down all the meters in Row B to below 10 cm. In Row D only meter D1 fell, though the rate of rise of D2 showed a check.

All the meters then rose steadily until further rain in August once more penetrated to 12 inches. It is noticeable that meters Z1 and Z2 both rose and fell more rapidly than the adjacent B1 and B2. The more rapid falls are clearly due to the proximity of the irrigation furrow, which, in heavy rainfalls as well as during irrigations, helped the water to penetrate (as, for instance, on 3rd September). The quicker rise of Z1, at 12 inches, is also probably due to the same cause, as well as to the fact that it was slightly more exposed to evaporation than B1, being further from the trunk. Z2 at 30 inches would not be liable to evaporation losses to any great extent, and here root

action appears to have withdrawn the water unequally from the soil regions round Z2 and B2. This is quite likely, for the holes for the Z meters were made with a small auger, so that few roots were disturbed, while the holes for the other meters were made with a spade, which, though small, would inevitably disturb more roots. It is clearly desirable to disturb roots as little as possible in putting in the meters, and to instal meters as long as possible before any trial is started.

Meters Z1 and Z2 both reached a tension of 50 cm. about 29th August, to be followed by B1, on 11th September, and B2 on 25th September. D1 and D2, comparable with B1 and B2, reached 50 cm. on September 25th. Thus the comparable meters on irrigated and non-irrigated plots reached 50 cm. within a few days. Resaturation to 8 cm. Hg occurred at 12 inches about 10th November, and at 30 inches about 6th December, on both plots.

It should be noted that in neither case did the main soil block become excessively dry before the fruit was picked. When the first irrigation was applied, the soil, although looking very dry on top, was shown by the meters to be relatively moist in the deeper layers. This irrigation was, in fact, probably largely wasted. Further, the moisture increase caused by these summer irrigations did not last appreciably into the autumn. Further discussion of these points appears later.

Storage Trials.

Two small trials were carried out with James Grieve fruits from the irrigated and non-irrigated plots, particularly with a view to finding whether "Bitter Pit", which is often severe in this variety, was increased.

In the first trial, 200 fruits of comparable sizes from each plot, picked on 4th September, were stored in a cool shed till 24th October. In the second 90 fruits from each plot, picked on 14th September were stored till 24th November. The results were as shown in Table III.

Table III.

Effect of Irrigation on Bitter Pit and Rots. Condition of Fruits at Final Examination.

	Sound.	Bitter Pit.	Rotten.	Internal Breakdown.
Trial I.				
Irrigated	159	1	20	20
Non-irrigated	193	0	7	0
Trial II.				
Irrigated	75	4	10	1
Non-irrigated	69	0	21	0

Out of the whole 580 apples, only 5 showed Bitter Pit. All these were from the irrigated plot, but it cannot be said that the incidence was appreciable. In rots, the result is indefinite. All the 21 fruits that developed internal breakdown were from the irrigated plot; but even here the incidence was very low; and as James Grieve is not a variety that keeps, this result cannot be regarded as very important.

Discussion and Conclusions.

In this trial the natural rainfall in June and July was enough to keep the bulk of the soil in the non-irrigated plot below a moisture tension of 30 cm. Hg (this was

confirmed by meters on various other plots). The soil remained, in fact, fairly moist. It is the more remarkable therefore that the moisture tension reduction resulting from the irrigation applied, a matter of some 10 cm. Hg, in the lower layers of soil only, near the tree, caused a significant increase in the size of fruit picked at the end of July. This beneficial effect was obtained by the application of water when the soil was well below the wilting point. This finding therefore agrees with the work of Aldrich and Work (1) and Lewis, Work and Aldrich (4) and bears out observations that the growth of apple roots in sandy and loam soils was retarded when the soil moisture tension exceeded about 30 cm. Hg (6, 9).

Much further work is clearly required before the exact optimum range can be established, however, and experiments with this end in view have been started.

With regard to the irrigation, it is clear that in the present experiment the water was used very wastefully. Five inches of irrigation water applied in the furrows did not moisten the soil in the centre of the tree-rows much more than one inch of rain. This was clearly because the irrigation furrows were too far apart to give thorough sideways wetting until so much water had been applied that much of it was lost by downward percolation, below the irrigation furrows, into the porous rock. More furrows, or the use of the basin method of irrigation (as recently advocated by Esselen (3) in South Africa), would clearly have moistened the whole soil block with the use of much less water.

In the present trial, the irrigation was clearly not economic, but with better use of the water applied, it appears quite possible that irrigation of apples would pay in certain areas of England, in dry summers.

Some sort of indicator of soil dryness conditions would clearly be desirable. In the absence of such, a large amount of guesswork is inevitable ; but it may be worth noting that, in the present trial, conditions in which irrigation gave positive results existed when, following only 0·71 inches of rain in May, the first fortnight of June had only 0·2 inches of rain.

The moisture meters proved of great value in showing the moisture conditions from day to day, and the percolation of rain and irrigation water. Meters placed at two depths, at two distances from irrigation furrows, appear to give an interesting view of the water movement ; but it is evident that a greater number of meters, and also duplicate sets of meters at varying points along the irrigated row, would be valuable in experimental work. The limited range of the meters did not prove a drawback in the present experiment.

The information gained from this preliminary trial was used in two subsequent irrigation trials with strawberries, which will be reported shortly.

Summary.

(1) The results of an apple irrigation trial at East Malling are described. Water equivalent to 8·9 inches of rain, given in two applications in June and July, by the furrow method, increased the size of fruits of Early Victoria and James Grieve by about 11 per cent.

(2) Moisture meters installed at 12 inches and 30 inches deep, in the tree row and also at 18 inches from the furrow, showed that the water penetrated sideways very much more slowly than downwards, and the centre strips were remoistened little more by 5 inches of furrow irrigation than by 1 inch of rain. Much of the irrigation water was probably lost in the underlying porous rock. The three furrows used,

between trees at 14 feet apart, were clearly not enough to give satisfactory water distribution.

(3) During most of the period of fruit swelling, the non-irrigated plot was kept at a moisture tension below 40 cm. Hg by natural rainfall, and the moisture tension of the irrigated plot was only about 10 cm. below that of the non-irrigated plot for much of this period. The improvement from irrigation appears therefore to have resulted from quite a small decrease in moisture tension. Neither plot became excessively dry and none of the trees reached the wilting point.

(4) A small storage experiment carried out with the James Grieve apples showed no appreciable increase of Bitter Pit in the irrigated fruits.

(5) The application of water given in this trial was not economic, but it appears that irrigation, suitably applied, would be justified in some areas in certain seasons in England. Moisture tensiometers appear to give a valuable guide to soil dryness.

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LOW TEMPERATURE INJURY TO FRUIT BLOSSOM

I. ON THE DAMAGE CAUSED TO FRUIT BLOSSOM BY VARYING DEGREES OF COLD

By C. P. FIELD

Introduction.

Symptoms of low temperature injury to the blossom of fruit plants have been recorded at East Malling in recent years when severe spring frosts were experienced. Observations showed that there was much to be learnt about the relative susceptibility of varieties to varying degrees of frost during blossoming, and about the nature of the damage which took place. In the spring of 1938, therefore, some preliminary studies were made on the effect of exposing apple and blackberry blossom to low temperatures under controlled conditions. The work was carried out at the Ditton Laboratory, where constant low temperature chambers were available. Determinations were made of the temperature at which injury first occurred, and that at which the flowers were severely damaged and the ovules killed. Sections of flowers exposed to low temperatures under various conditions were cut and a microscopic examination made to determine the regions affected and the nature of the damage. The effects of the following factors on freezing injury to apple blossom were also studied. (1) The duration of exposure. (2) The temperature following the freezing treatment. (3) The rate of cooling and thawing. (4) The presence of moisture on the blossom. (5) The stage of flower development. (6) "Hardening" of blossom by previous exposure to non-injurious low temperatures. (7) Introduction of substances such as glycerin, urea, or sugars, in an attempt to increase resistance.

Material.

Apple. Owing to the frosts which injured the flowers of most apple trees in the spring of 1938, only late flowering varieties were available for study. Blossom was used from several eighteen-year-old trees of Court Pendu Plat, and from an unworked specimen "Crab" apple tree of the clonal rootstock A. In both varieties the blossom was cut off with wood varying from 1 to 12 inches in length.

Blackberry. When the blossom of the late flowering apple varieties was over, studies were continued on blossom from some four-year-old plants of Himalaya blackberry.

Experimental Technique for Cooling Blossom.

Throughout the experiments described below, blossom was used both freshly cut, and stored overnight at 50° F. with the cut ends of shoots in water. No differences in amount or type of damage were seen between the samples of blossom treated in these two ways, nor were there any noticeable variations due to differences in length of wood carrying the blossom.

Samples of blossom were placed directly into constant temperature chambers at 32°, 30°, 29°, 28°, and 26° F. for periods of one, three, six and twelve hours. The blossom was exposed on a table in the chamber with the cut end of the shoot covered with a pad of damp cotton-wool applied in the field when the twig was cut.

The rate of cooling of single flowers was measured when they were transferred from normal air temperature to 26° F., and it was found that the flowers cooled so quickly (within six minutes) that it was not necessary to make any adjustment for cooling, to the times of exposure in the following experiments.

The Nature of the Low Temperature Damage.

The symptoms of damage occurred in the same characteristic sequence, whether produced by a short exposure at a relatively low temperature, or a longer exposure at a slightly higher one.

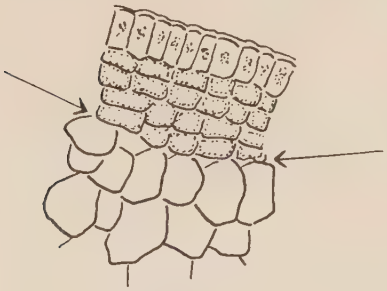

Fig. 1.
Transverse section of outer layers of cells in apple ovary, showing where skin loosening occurs, indicated by arrows.

Apple. There were two main types of injury, (1) the skin of the ovary (young fruit) became loosened, and (2) certain cells within the ovary showed a brown discoloration of the tissue and were killed. The loosening of the ovary skin, which occurred without any browning of the cells concerned and was the first apparent injury in Crab A, began from the eye or stylar end and progressed downwards to the stalk. The skin could then be peeled off quite easily. Microscopic examination of transverse sections showed that the break accounting for this loosening occurred four to six cells below the cuticle, where the cells were smaller, more uniform, had thicker walls and more chloroplasts and appeared to be more densely granular than the main cortical cells. The dividing line, where the break away of the skin occurred, lay between these two types of cells. (Fig. 1.) In the second type of injury, browning of the styles, placenta and ovules was visible, in addition to the loosening of the ovary skin, and the discoloration started in the styles and spread from small patches near the "eye" end, at the base of the styles and sepals, through the centre of the ovary and finally to the ovules. The petals, and sometimes the stamens, turned brown, and the latter occasionally orange. Usually, no damage was visible in the main flesh of the ovary. The sequence of browning is shown in the diagrams of longitudinal sections of ovaries in Fig. 2. Similar blossom damage was seen in the field under natural frost conditions in many varieties, e.g., Bramley's Seedling, Lane's Prince Albert and Cox's Orange Pippin. Although the brown discoloration was

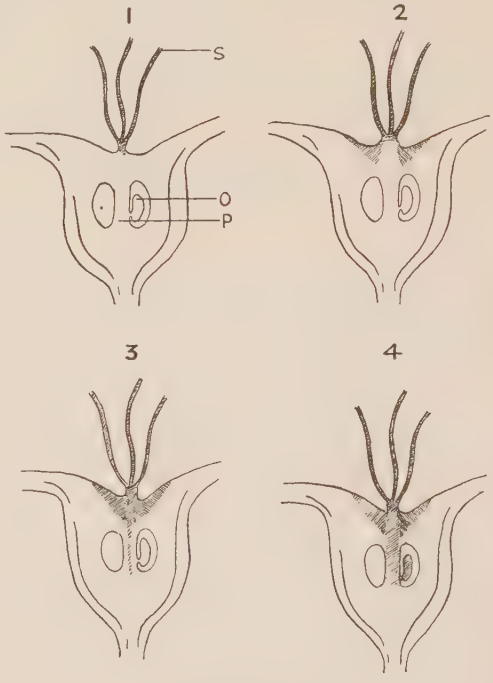

Fig. 2.
Diagrams of longitudinal sections of apple ovaries, showing sequence of browning damage indicated in shaded areas.
S = Style ; O = Ovule ; P = Placenta.

confined to definite areas, as a rule there were no outstanding differences in the character of the cells in these regions. In some of the more mature flowers, however, the cells at the apex of the ovary near the point of attachment of the styles, where browning first occurred, did appear to differ from the other adjoining ones, in having comparatively thick walls. Tetley describes these cells as being later concerned in cork formation (9). It was often in this region that the corky frost scars were seen in fruits which developed in the field.

In the placenta those cells near the inner vascular bundles were damaged first, but eventually, after longer exposures to the freezing temperature, all the placental cells were injured.

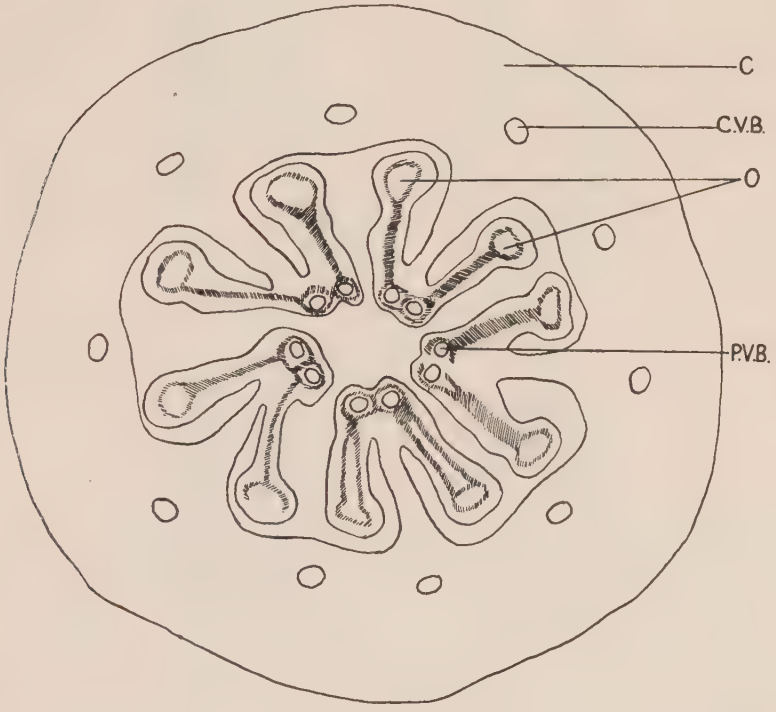

FIG. 3.

Diagram of transverse section of apple ovary showing browning injury in the placenta and ovules.
C=Cortex ; C.V.B.=Vascular bundles of cortex ;
P.V.B.=Vascular bundle of placenta ; O=Ovules.

Browning of the cells was not observed near the main outer vascular bundles of the cortex ; it was always concentrated towards the centre of the ovary, as can be seen in Fig. 3, which represents a transverse section.

Damage in the ovules was at first confined to a few layers of cells where the protoplasm appeared to be more granular at a depth of three to four cells below the outermost ones, but in more severe cases of injury all the ovule cells were damaged.

In these two varieties there were no outstanding variations in the thickness of the epidermis and cuticle at the " eye " or stylar end of the ovary which might account for the larger amount of injury in this region, nor were there any marked differences in the

number and distribution of stomata, although the epidermal hairs were generally more numerous near the apex of the ovary.

Blackberry. The first sign of damage in blackberry flowers was the browning of the styles. After longer exposures to the same low temperature this spread to the outer rim of the drupels and to the edge of the receptacle. Later the stamens and finally the drupels and receptacle became completely brown. The sequence of damage is shown in diagrams of longitudinal sections of flowers in Fig. 4.

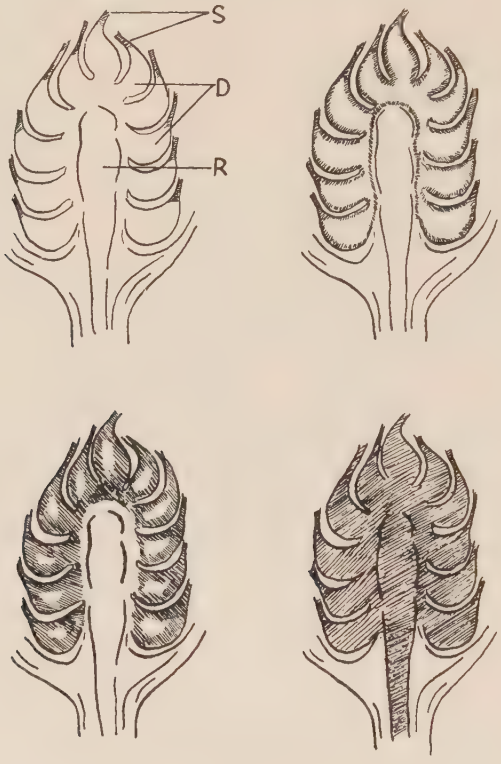

Fig. 4.
Diagrams of longitudinal sections of blackberries, showing sequence of browning injury indicated in shaded areas.
S = Styles ; D = Drupels ; R = Receptacle.

The Effect of Varying Conditions upon Injury Due to Low Temperature.

The Effect of Temperature and Duration of Exposure.

Temperatures of 32° or 30° F. produced no visible damage in apple flowers even after twelve hours exposure, but both varieties were injured at 29° F. The symptoms of injury resulting from direct exposure to 29°, 28° and 26° F. are illustrated in Fig. 5 which represents longitudinal sections of flowers. In general, the same type and amount of damage resulted from short exposure to comparatively low temperatures as from longer exposure to slightly higher temperatures. The amount of injury increased according to the length of exposure up to six hours at 28° or 26° F., and up to twelve hours at 29° F.

It is of interest to note that Potter (7) and Hildreth (5) working with apple roots and shoots, also found that the amount of damage was proportional to the duration of exposure.

Crab A. Crab A blossoms subjected to a temperature of 29° F. were undamaged until after three hours exposure after which period they first showed slight skin loosening and brown petals. After a further three hours the skin was completely loose and the styles and placenta turned brown, but it was not until twelve hours had elapsed that the ovules were affected.

A lower temperature of 28° F. produced slight skin loosening in two hours, while the same stage was reached at six hours which took twelve hours to develop at the higher temperature.

One hour at 26° F. was sufficient to start slight loosening of the skin, the process being completed in two hours. An hour later, petals, stamens, placenta and ovules were all affected, the flowers having reached very nearly the same stage in three hours as that which took twelve hours to develop at 29° F.

Court Pendu Plat. The process of skin loosening took longer to develop in Court Pendu Plat ; in fact at 29° F. no damage at all was apparent until six hours had elapsed. Now, however, while the skin was only slightly loose, the browning of the placenta and ovules was much more severe than in Crab A. A further six hours at this temperature completed the loosening of the skin, but only slightly increased the other damage.

The sequence of events was nearly identical at the two lower temperatures 28° F. and 26° F., but in both chambers the time taken to complete the process was half that at 29° F. At the lower temperature (26° F.), however, the stamens turned brown at the same time as the other parts of the flower.

The Temperature Following the Freezing Treatment.

The damage produced by these low temperatures was not visible until after the blossom had been removed from the cold chambers to a higher temperature for a period.

In the foregoing comparisons all the blossom was kept at 50° F. before the relative amount of damage was assessed. Some damage was apparent after five or ten minutes at this temperature ; but, generally, the full amount was not disclosed until a full hour had elapsed, as a rule little further injury being revealed by a second hour at the same temperature. Longer periods were required at a temperature of 39° F. to show the same amount of injury, but at a temperature of 60° F. additional damage appeared in Crab A flowers, which took the form of a circular brown patch at the base of the styles on the surface of the ovary.

Effect of Slow Cooling and Gradual Thawing.

Injury in blossom which was cooled slowly to 26° F. and allowed to thaw gradually was compared with that produced by transferring blossom directly from normal temperature to 26° F. The slow cooling was obtained by transferring samples of blossom in tins, with the lids partly on, from 50° F. to 39° F. for six hours, then to 32° F. for twelve hours and finally to 26° F. When the blossom was examined after exposure to 26° F., it appeared that slow cooling did have some effect in slightly retarding the damage, with one exception. Court Pendu Plat showed ovary skin loosening sooner with a more gradual fall in temperature. These results are shown in Table I, and are in agreement with the work of Chandler, who found that rapid cooling increased the severity of injury in apple buds (2).

Other samples of blossom, cooled slowly as described, were allowed to thaw gradually by transferring them from 26° F. to 32° F. for twelve hours, to 39° F. for six hours and finally to 50° F. In these samples of blossom the rate of thawing did not appear to affect the type or amount of damage, although, as already described, where thawing of Crab A flowers was very rapid, as a result of subjection to 60° F. following 26° F., they showed more severe damage than after slightly slower thawing at 50° F. In this connection it is interesting to note Chandler's finding that the rate of thawing did not affect low temperature injury in apple fruitlets, though in mature fruits rapid thawing caused more severe injury.

The Effect of Wetting the Blossom.

In order to discover whether moisture on the flowers during cooling affected the damage, samples of apple blossom were made thoroughly wet by immersion in water

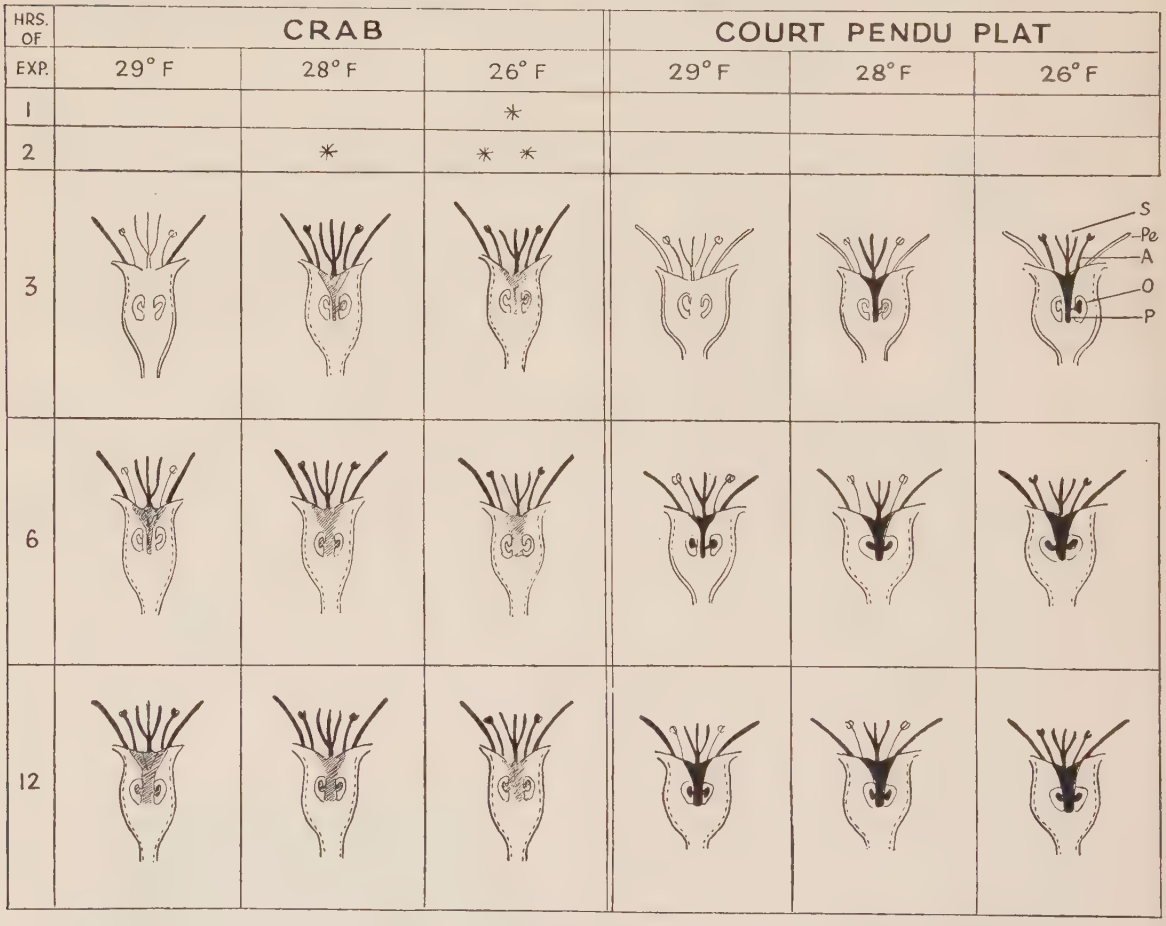

FIG. 5.

Diagrams of longitudinal sections of apple flowers showing the sequence of damage (in Crab and Court Pendu Plat) produced by exposure to varying periods at 29°, 28°, and 26° F.

*=slight skin loosening
**=complete skin loosening
} also indicated by dotted lines in flower sections.

Browning shown in shaded areas.

S=Style; Pe=Petal; A=Stamen; O=Ovule; P=Placenta.

overnight at 50° F. before being transferred to a chamber at 29° F. Samples of normal dry blossom, cut at the same time and kept at 50° F. with the cut ends of shoots in

TABLE I.

TIME TAKEN FOR SYMPTOMS OF LOW TEMPERATURE INJURY TO DEVELOP WITH RAPID OR SLOW COOLING.

Symptom of Injury.	Treatment.	26° F.	
		Crab.	C.P.P.
		Hours.	Hours.
Ovary skin slightly loose ..	Rapid cooling ..	1	3
	Slow cooling ..	2	2
Ovary skin completely loose	Rapid cooling ..	3	6
	Slow cooling ..	4	4
Styles and part of placenta brown	Rapid cooling ..	3	3
	Slow cooling ..	6	6
Anthers become orange ..	Rapid cooling ..	3	3
	Slow cooling ..	4	4

TABLE II.

TIME TAKEN FOR SYMPTOMS OF LOW TEMPERATURE INJURY TO DEVELOP IN NORMAL DRY AND WET BLOSSOM.

Symptom of Injury.	Condition of Blossom.	29° F.	
		Crab.	C.P.P.
		Hours.	Hours.
Ovary skin slightly loose ..	Normal dry ..	3	6
	Wet	1	3
Ovary skin completely loose	Normal dry ..	6	12
	Wet	3	6
Petals brown	Normal dry ..	3	6
	Wet	2	2
Anthers brown or orange ..	Normal dry ..	12	—
	Wet	6	6

water, were placed in the same chamber for comparison. Wet flowers were found to be more susceptible to skin loosening, petal and stamen damage than dry flowers (Table II). A similar result was obtained with freshly cut flowers exposed in the same chamber in

tins with the lids partly on ; under these conditions moisture collected in considerable quantity on the inner sides of the tins, showing that the air in the tins was saturated.

Differences in Susceptibility to Low Temperature Injury of Flowers in Various Stages of Development.

In the various experiments described, marked differences in susceptibility to injury were noticed in the buds, open flowers, and more advanced stages of flower development.

TABLE III.

COMPARISON OF LOW TEMPERATURE INJURY TO BUDS AND OPEN FLOWERS.

Symptoms.	Temp. ° F.	Crab.		Court Pendu Plat.	
		Bud.	Open.	Bud.	Open.
Ovary skin loose ..	29	3	3	6	6
	28	2	2	3	3
	26	1	1	3	3
Petals brown	29, 28, 26	6	3	3	6
Degree of browning injury in the ovary	29	6 Slight.	6 Severe.	6 Severe.	6 Slight.
	28, 26	3 Slight.	3 Severe.	3 Severe.	3 Slight.

TABLE IV.

SHOWING MOISTURE CONTENT OF FLOWERS IN VARIOUS STAGES OF ADVANCEMENT.

	Crab A.	Court Pendu Plat.
Flowers over	77%	77%
Flowers open	82%	82%
Opening buds	82%	82%
Closed buds	80%	80%

Chandler (2) and Young (10) considered that the buds were more resistant than the open flowers. Table III shows that, though this was borne out in Crab A flowers, as regards browning injury, the reverse was true for Court Pendu Plat. It was evident that in this variety no appreciable protective influence could be attributed to the sepals and petals of buds, as compared with those of open flowers, since injury was greater in the buds. It seemed possible, however, that differences in moisture content might account for these variations in susceptibility, since it has been found by several workers that the moisture content of frost resistant plants is relatively low. Clements showed that the older more

resistant needles of pines and firs have a lower percentage moisture content than the young susceptible leaves (3). The moisture content of flowers in various stages of development was estimated by drying them over calcium chloride in a desiccator, but the differences were found to be very slight (Table IV). Although the buds of Court Pendu Plat were more susceptible than those of Crab A, they apparently contained the same amount of water.

Effect of Hardening the Blossom.

There is evidence from previous work on freezing that hardiness can be induced in plant material by exposure to relatively low, but non-injurious, temperatures for considerable periods before freezing. Harvey (4) obtained hardiness in elm seedlings as a result of exposure to 0° C. for five days, and Chandler (2) in apple roots kept in cold storage at temperatures of 31°-32° F. and 39° F. Chandler also noted that hardiness in dormant peach buds was increased by exposure to continuous cold preceding the injurious low temperature.

TABLE V.

TIME TAKEN FOR SYMPTOMS OF LOW TEMPERATURE INJURY TO DEVELOP IN NORMAL AND RETARDED BLOSSOM.

Symptom of Injury.	Conditions.	Court P.P.	
		28° F.	26° F.
		Hours.	Hours.
Ovary skin slightly loose ..	Normal	3	3
	Retarded	3	3
Ovary skin completely loose	Normal	6	6
	Retarded	6	6
Styles and part of placenta brown	Normal	3	3
	Retarded	1½	1½
Ovules become brown ..	Normal	3	3
	Retarded	9	3

Large branches of Court Pendu Plat were cut, while the flowers were still in bud, and kept at 38° F. for four weeks, followed by two weeks at 34° F. The flowers were retarded so greatly that they did not open until after the sixth week, but otherwise they appeared to be normal. Yet, as Table V shows, when exposed to temperatures of 28° and 26° F., no greater resistence was observed in the retarded blossom, except that at a temperature of 28°, the ovules did not show injury until after twelve hours, instead of three hours as for normal blossom. Otherwise, the first sign of browning injury occurred sooner in retarded blossom (i.e. after 1½ hours at 28° or 26° F. instead of three hours).

Effect of Introducing Solutions of Various Substances.

An increase in frost resistance has been obtained by several workers by the introduction into the plants of such substances as glycerin, urea and sugars. Akerman (1)

and also Iljin (6), found that frost resistance of red cabbage leaves was raised by immersion in dilute glycerin and to a certain extent by solutions of urea.

Observations were made, therefore, on samples of blossom which had been previously treated with solutions of glycerin, urea or dextrose, either by injection of shoots on the plants or by placing the cut ends of blossoming shoots in the solutions. The method of injection was similar to that described by Roach (8). Blackberry blossom was used for these experiments as apple flowers were not available at this time.

Blossoms treated with 1 per cent. or 5 per cent. dextrose, or with 0·5 per cent. or 1 per cent. urea, were no less susceptible to low temperature injury than normal blossoms. Injection with 5 per cent. glycerin, however, definitely increased resistance, as these flowers withstood up to twelve hours at 28° F., and three hours at 26° F., without any injury and were only slightly damaged after six hours at 26° F. Non-injected blossom was damaged after only two hours at 28° F. or one hour at 26° F. and very severely injured after six hours at 26° F. Injections with 1 per cent. glycerin also produced resistance, but this was less marked than with 5 per cent. as can be seen in Table VI.

Table VI.

Low Temperature Damage Produced in Normal and injected Blackberry Blossom.

Temperature.	Hours of Exposure.	Control non-injected.	5% glycerine injected.	1% glycerine injected.
26° F.	1	Slight.	None.	Slight.
	2	Severe.	,,	,,
	3	Severe.	,,	,,
	6	Very severe.	Slight.	,,
	12	Very severe.	Slight.	Severe.
28° F.	2	Very slight.	None.	None.
	3	Slight.	,,	Very slight.
	6	Severe.	,,	Slight.
	12	Very severe.	,,	,,

No differences in frost resistance were seen in blossom injected for varying periods with glycerin. The flowers had absorbed enough glycerin within one day, and a more prolonged injection gave no increase in resistance.

Discussion.

The two types of low temperature injury observed appear to be quite distinct, since skin loosening of the ovary did not result in any apparent killing of the cells. In fact it is considered that this damage was not necessarily permanent, for many blossoms thus injured under natural conditions, appeared to recover later with the skin once more firmly adhering. The browning damage, however, seemed to be lethal, the cells concerned being disintegrated, and might be expected therefore to affect the fruit. This could not be proved in these experiments, since the blossom was removed from the tree. Further evidence, indicating that the cause and nature of the damage in one type of injury are quite distinct from those in the other, is provided by the fact that Court Pendu Plat proved to be more resistant to skin loosening than Crab A, although the ovaries are more susceptible to browning injury. Again, although the buds and open flowers of both varieties were equally susceptible to skin loosening, considerable differences were found in resistance to browning in the ovary.

In the second type of injury, although the actual killing did not become apparent until the tissues were thawed (since no brown discoloration of the cells was visible until they had been removed from the low temperature to a higher one for a period), it seems probable that the cells were dead before they showed this brown coloration.

The varying temperatures (below 32° F.) did not produce different types of injury, but the sequence and type of damage was constant whether produced by short exposures at 26° F. or longer exposures at 29° F.

After injury to the styles, the damage resulting in browning of the cells was confined to the centre of the ovary, although it might be presumed that these regions were more protected than the outer cortical areas of the ovary, which showed no damage at these particular temperatures. It is interesting to note that there was always a definite and connected " path " in the sequence of the damage from the styles through the centre of the ovary to the ovules, and that in general this did not appear to be related to any particular type of cell. In the placenta, however, browning occurred first in the immediate vicinity of the inner vascular bundles.

The varietal differences in susceptibility remained constant regardless of treatment. It appeared that it was not so much the anatomical structure of the flower which was important as some quality in the cell protoplasm. Court Pendu Plat blossom was much more resistant to skin loosening than Crab A, but the skin thickness was about the same in the two varieties, as was shown by an examination of the anatomical structure of the epidermis and cuticle near the style end, where susceptibility to both skin loosening and browning was greatest. On the other hand the petals of Crab A flowers, which were less resistant than those of Court Pendu Plat, were obviously different in being comparatively long, thinner in texture, and more widely spaced.

The varietal differences in susceptibility were most marked in the behaviour of the flowers at different stages in their development. From these investigations it cannot be said that flowers of all varieties are more resistant when in bud, since, although this proved to be the case for Crab A flowers, the reverse held for Court Pendu Plat.

Moisture appears to be important since wet flowers proved more susceptible than dry ones. Relative hardiness of buds and open flowers, however, could not be correlated with varying moisture content.

Acknowledgements.

The writer wishes gratefully to acknowledge the assistance of the Superintendent of the Ditton Laboratory, Dr. C. West, who provided facilities for the carrying out of this work, and the guidance of Mr. J. K. Hardy on method of technique, and the advice given by Mr. T. N. Hoblyn and Miss A. B. Beakbane in the presentation of this paper.

Summary.

Observations are reported on the nature of the damage to blossom of two varieties of apple (Crab A and Court Pendu Plat), when cut from the tree and exposed to low temperatures in constant temperature chambers. The damage was found to be similar to that in the field under natural frost conditions.

The injury resulting from exposure for different lengths of time to various temperatures below 32° F., is described and the order of its occurrence is recorded. Temperatures at or below 29° F. caused damage which was proportional to the duration of exposure.

Varietal differences in susceptibility to low temperature injury are discussed.

The nature of the damage, and the time taken for it to develop, were found to be modified by the temperature following exposure in the cold chamber.

Slow cooling appeared to have the effect of retarding the appearance of damage, but in general the time taken in thawing was unimportant.

Wet blossom at similar temperatures was affected sooner than dry blossom.

The relative susceptibility of the two varieties at different stages of development of the flowers was found to be different.

Attempts to " harden " blossom by keeping it at 38° F. and at 34° F. for several weeks before freezing, did not have much effect in producing resistance.

Of substances injected into the shoots and flowers of blackberry, only glycerin reduced susceptibility. Solutions of sugar and urea had no effect.

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A FURTHER EXPERIMENT IN THINNING THE FRUIT OF VICTORIA PLUMS

By A. C. PAINTER and B. L. WATES

A PREVIOUS experiment carried out on Victoria plums in 1930 to compare the effect of thinning against no thinning, clearly showed the advantages of thinning the crop of heavily laden trees (1), (2). Thinning definitely increased fruit size, gave a higher net return for the fruit in spite of a lower aggregate yield, and reduced the damage resulting from breakage of branches due to wind and overloading. General experience has since confirmed those results.

In 1936 the set was again heavy and the present experiment was designed as one of a series to obtain information regarding the effect of different degrees of thinning. Broad rather than small differences are being looked for.

Material and Technique.

Sixty trees in all were used, twenty-four on Brussels stock, twenty-four on Common Plum and twelve on Myrobolan C. Most were fourteen year planted, and the rest nine.

The fruit on half the trees on each stock was thinned to approximately one inch apart, i.e. the fruit was not allowed to remain closer on an average than one inch between the stalks; no doubles were allowed. Actually the effect of this was, that where the fruit had set in clusters, the distance apart of a number of plums after thinning would be something as follows: $\frac{3}{4}$ inch, 1 inch, $1\frac{1}{4}$ inches, 1 inch, $\frac{7}{8}$ inch, $1\frac{1}{3}$ inch and so on. In places, however, where the set was sparse, the distance would be greater, perhaps 2, 3 or 4 inches.

On the other half the fruit was thinned in a similar manner to approximately 2 inches apart. Thinning was carried out between 19th and 23rd June.

The following observations were recorded:

(1) The weight of thinnings and the number of fruits in three separate 1 lb. samples from each tree. From this the amount of fruit removed was estimated.

(2) The weight of fruit and the number of fruits in a 3 lb. random sample from each tree at each picking.

(3) When picked the fruit from each stock and each thinning treatment was size-graded under different quality grades.

For the sake of convenience trees with fruit thinned to one inch are referred to as lightly thinned and those to two inches as heavily thinned.

Proportion of Crop Removed at Thinning.

The proportion of the crop removed at thinning is shown in Table I.

This Table also shows the comparative crops of the trees on the different rootstocks relative to their size. This has been calculated from trunk thickness, which has been found to be a satisfactory measure.

TABLE I.

Stock.	Lightly Thinned.		Heavily Thinned.	
	Relative Crop.	% removed at Thinning.	Relative Crop.	% removed at Thinning.
Common Plum	53	61	52	68
Brussels	36	52	36	63
Myrobolan C.	32	48	27	60

There are several points which may be noted for a proper understanding of the deductions drawn from this experiment.

(1) The percentage of fruit removed at thinning is not the same for all three stocks. The reason for this is to be found in the differences of the crops from trees on the different rootstocks. It may be noted that although the trees on Myrobolan C had considerably the smallest crops for their size, as the trees were very much larger the actual crops were bigger (see Table III).

(2) Within any one thinning treatment the trees which had the heaviest relative crops, as might be expected, also had the largest percentage of fruit removed. This effect was more pronounced in the lightly thinned trees.

(3) Doubling the distance apart of thinning did not mean a corresponding increase in the amount of fruit removed. Actually the increase was surprisingly small, only amounting to some 25% with Myrobolan, 21% with Brussels and as little as 11% with Common Plum, that is, the heavier the crop the less difference there was in the amount of fruit removed by the two treatments. It would not appear that this can be accounted for by differences in the relative crops borne by the two sets of trees, for only with Myrobolan was the difference appreciable ; with Common Plum and Brussels crops were practically identical. The most probable reason was the uneven spacing of the fruit before thinning took place. Sometimes the fruitlets were in thick clusters necessitating large numbers being removed over a short length, whilst in places it was already spaced to such a distance apart that in neither thinning treatment was it necessary to remove any fruit at all.

Effect on Fruit Size and Quality.

The trees were picked over on 26th August and 2nd September and cleared on 11th September. At each picking counts were made of the number of plums in one random sample of 3 lb. from each tree. The results are given in Table II. and show that for each

TABLE II.

AVERAGE NUMBER OF PLUMS IN A 3 LB. SAMPLE—FIRST TWO PICKINGS.

Rootstock.	No. of trees.	Lightly Thinned.	Heavily Thinned.	Significant Difference.
Brussels	12	40·1	37·6	2·4
Common Plum	12	44·1	41·3	2·6
Myrobolan C.	6	47·2	38·3	7·5
Altogether	30	43·1	39·2	2·8

Table III.

Total Crop in Half-Sieves (24 lb.) per Acre in Each Grade and Net Market Value.

	Approx. No. to lb.	On Brussels.				On Common Plum.				On Myrobolan C.				All Stocks Combined.			
		Heavily Thinned.		Lightly Thinned.		Heavily Thinned.		Lightly Thinned.		Heavily Thinned.		Lightly Thinned.		Heavily Thinned.		Lightly Thinned.	
		Crop.	%	Crop.	%	Crop.	%	Crop.	%	Crop.	%	Crop.	%	Crop.	%	Crop.	%
Extra Selected and Selected (N.M.) (over 1½ ins. in diam.)	9	249	24	232	19	285	27	180	15	377	29	217	11	304	27	210	15
Grade I. (1¼–1½ ins.)	12	578	55	635	53	590	55	616	53	686	53	927	49	618	54	726	51
Grade II. .. (1⅛–1¼ ins.)	18	180	17	258	21	161	15	290	25	190	15	487	26	177	16	345	24
Grade III. (under 1⅛ ins.) ..	23	38	4	83	7	29	3	89	7	39	3	264	14	35	3	145	10
Total		1,045		1,208		1,065		1,175		1,292		1,895		1,134		1,426	
Value		£92		£97		£93		£85		£120		£130		£102		£104	
Value per ½-sieve														1·10		1·6	

Note.—(1) For the sake of comparison it has had to be assumed, when calculating market value, that the entire crop consisted of sound fruit. To obtain the actual value received it is necessary to deduct about 12 per cent. on account of wasty and blemished fruit.

(2) The trees on the three stocks are all planted at 15 ft. sq. and the acreage yields are calculated on this basis. The fact that the trees on Myrobolan C are considerably larger than the others and would not be planted at the same distance in commerce does not affect the validity of the comparisons under discussion.

rootstock larger fruit, i.e. a less number per sample, was harvested from the heavily thinned trees. The differences necessary to give a twenty to one chance in favour of significance are given in the third column and show that on all stocks the differences were significant.

The fruit from each stock and treatment was machine graded in bulk into four different size grades (Table III). In each case the more heavily thinned trees produced both actually and proportionately more fruit of National Mark size and far less small fruit (grades 2 and 3) than those that had been lightly thinned.

There was no apparent difference in market quality between fruit of the same size grade from heavily thinned and lightly thinned trees. There was, however, a considerable difference between fruit of different sizes. The Selected grade consisted entirely of fruit of a good bright red colour with a yellow back-ground. Grade 1 fruit too was mainly of good colour, but some of it had a distinctly dull appearance, while grades 2 and 3 consisted almost entirely of fruit of a dull muddy red.

The proportion of blemished fruit was almost identical for all stocks and treatments.

Maturity.

Fruit from the heavily thinned trees matured earlier than that from the lightly thinned, as evidenced by the larger proportion harvested from the former at the first picking in each instance (Table IV). These results were statistically significant for Brussels and Common Plum and, though not quite significant for Myrobolan C, owing to the fewer trees involved, nevertheless the tendency was the same, thus confirming the general result. As early plums often command a higher price on the market than later fruit, heavy thinning may prove useful in this respect, particularly in an early district.

Table IV.

Influence of Thinning on Time of Ripening as Shown by the Percentage of the Total Crop Harvested at The First Picking.

Stock.	Lightly Thinned.	Heavily Thinned.	Significant Difference.
	%	%	
Brussels	11·5	24·1	8·6
Common Plum	17·6	29·1	10·7
Myrobolan C.	7·5	12·8	7·1
Altogether	13·1	23·8	5·8

It is interesting to note the differences in time of ripening of fruit from the three rootstocks. Both Common Plum and Brussels ripened their fruit in advance of Myrobolan ; that Common Plum was so much in advance may be due to the fact that the trees on that stock were less shaded by neighbouring trees than those on Brussels and Myrobolan. In this connection previous observations have shown that Czar on Brussels also tends to ripen its fruits earlier than trees on Myrobolan stocks (3).

Effect of Thinning on Subsequent Crop.

With an occasional exception all trees carried greatly reduced crops in 1937. The heavily thinned trees on Common Plum and Myrobolan carried a somewhat larger crop on the average than the lightly thinned. With Brussels the reverse was the case. Differences, however, were not such as to enable them to be correlated with the different thinning treatments carried out in 1936.

The Economic Aspect.

Figures are given showing the actual returns from the two treatments on an acreage basis (Table III). Whether they are taken as they stand or whether some allowance is made for any differences in the relative crops of sets of trees that are being compared (Table I) the difference in market value is not sufficiently large to allow definite deductions to be drawn, for it must be remembered that, whilst it may be possible from even one year's results to estimate with a fair degree of certainty what will be the comparative effect in any given year of different thinning treatments upon fruit size, such cannot be said to be the case where market value is concerned. Prices may vary considerably from year to year, e.g. in the present instance Grade 2 fruit gave a moderate net return ; in another year such fruit might be almost valueless. The lower the value of the smaller fruit the more favourable is the effect of heavy thinning likely to be on the total net return.

In comparing the two treatments the cost of thinning does not arise as, in effect, including the thinning operation, all trees were picked over the same number of times.

The value of the crop has been based on the average prices received over the whole season, less all packing, grading, transport, storing, and marketing charges (Table V) ; this is thought to be fairer than just taking the price for the actual days on which fruit from the thinning experiment was marketed. It has been necessary to take these charges into account as they differ considerably for the different grades and consequently figures based on gross value alone would be misleading.

TABLE V.

MARKET VALUE AND COST OF MARKETING (PER HALF-SIEVE OF 24 LB.).

	SELECTED (National Mark). d.	GRADE 1. d.	GRADE 2. d.	GRADE 3. d.
Average gross market return	58	36	26	17
Grading, marketing and storage costs ..	20	18	14	15
Net return	38	18	12	2

NOTE.—The fruit was not all marketed in the same kind of package, but in the way that was considered to be to the best advantage at the time. Thus the Selected fruit was marketed in 6 lb. and 12 lb. chips, the majority of Grade 1 in 12 lb. chips and the remainder in half-sieves, Grades 2 and 3 entirely in half-sieves.

DISCUSSION.

A one year's experiment of this nature must have its limitations, and, unless large differences are obtained, results tend to serve as indications rather than as data from which definite conclusions can be drawn.

That there were not greater differences in the present instance is almost certainly due to the comparatively small difference in the amount of fruit removed by the two treatments. It would have undoubtedly served the purposes of the experiment better to have had greater extremes and this was actually intended, but it was not anticipated the difference in the amounts of fruit removed would have been so small.

One fact that emerges, however, is the comparatively small proportion of fruit of National Mark size (i.e. over $1\frac{1}{2}$ inches in diameter) picked from either the heavily or

the lightly thinned trees, and the large quantities of Grade 2 and Grade 3 fruit. As these trees are healthy and vigorous and in years of lighter crops are capable of producing fruit of good size (in 1937 when the average crop was two half-sieves per tree about 50 per cent. of the fruit picked was of National Mark size)—it would seem that, if it is desired to obtain a larger proportion of good sized fruit, it may be necessary in years of heavy crops to thin the fruit of such trees to as much as three inches apart or perhaps even more. As soon as opportunity offers a further experiment will be carried out to test this.

Acknowledgement.

The writers are particularly indebted to Mr. T. N. Hoblyn who, apart from assisting to plan the experiment and making the usual statistical analyses, went very fully into certain other data affecting the interpretation of the results.

Summary.

(1) Results are given of an experiment to test the relative effect of thinning the fruit of heavily laden Victoria plum trees as far as possible to (*a*) one inch apart and (*b*) two inches apart between the stalks.

(2) Whilst the difference in the amounts of fruit removed by the two treatments was not as large as had been expected, the more heavily thinned trees produced considerably more fruit of large size and far less fruit of small size than the lightly thinned trees.

(3) No difference in market quality could be discerned between fruit of the same size from the two treatments. There was, however, a marked difference in appearance and finish between fruit of different sizes.

(4) Fruit from the heavily thinned trees matured earlier than that from the lightly thinned.

(5) It has not been found possible to correlate differences between the crops of heavily and lightly thinned trees in 1937 with the different thinning treatments of the previous year.

(6) The economic aspect is reviewed. In the present instance there was little difference in the market value of the fruit from the two treatments.

(7) Certain points arising from the experiments are discussed. Under the conditions prevailing neither treatment produced any large proportion of fruit of National Mark size. To have done so would have necessitated more drastic thinning.

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WEATHER CONDITIONS DURING 1938

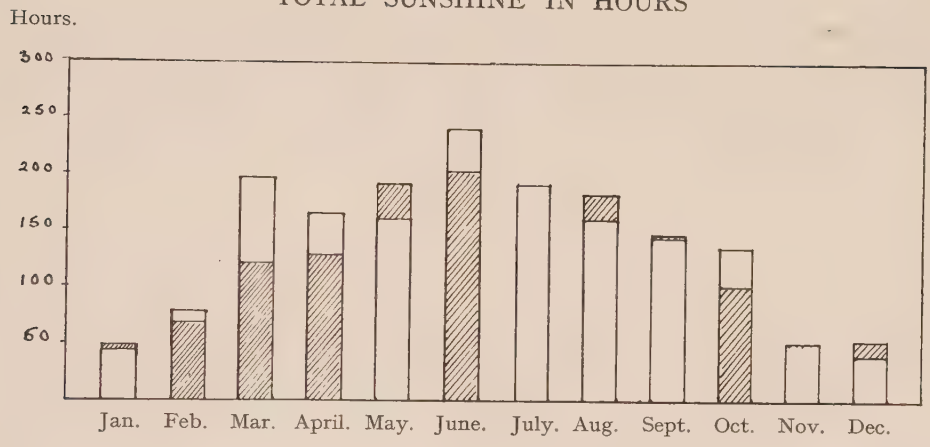
By H. C. CHAPELOW and H. M. TYDEMAN

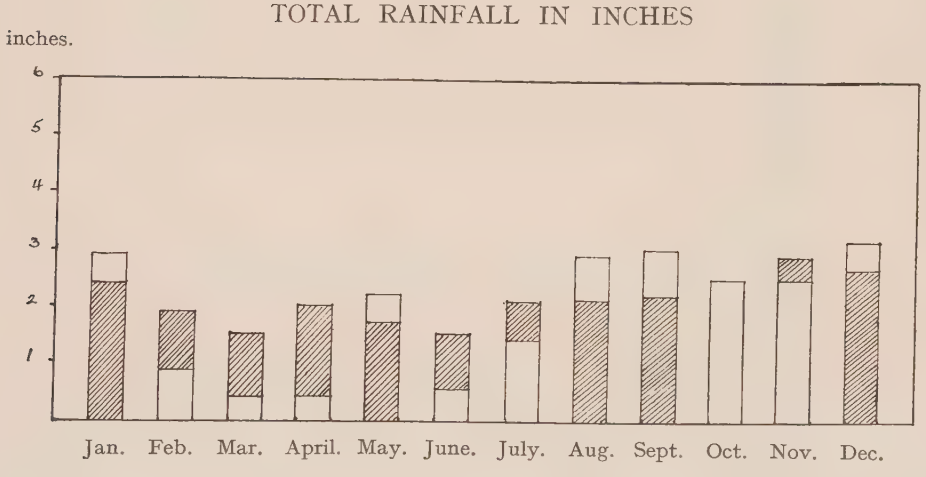
SPEAKING generally, 1938 was somewhat dry with much more than average sunshine. Following a rather wet and mild January, conditions throughout the spring were dry and sunny. Exceptionally warm and sunny weather was experienced throughout March, when sunshine was seventy-nine hours in excess of the normal, and rainfall was notably deficient. This weather brought all varieties of hardy fruits into blossom several weeks before the normal time. Severe conditions during April and early May caused great damage to the blossoms and partially ruined the prospects of an excellent crop. Throughout this period continuous northerly winds were recorded for thirty-eight days in succession and it is probable that these were almost as largely responsible for the damages to vegetation as were the ground frosts, which occurred with great frequency. An average rainfall in May compensated to some extent for the dry conditions of February, March and April, but after a dry June and July plants were again experiencing a deficiency of moisture. Harvesting operations were carried out under somewhat variable conditions. Close and thundery weather persisted throughout the earlier part of August, and thunderstorms were relatively frequent. During one very severe storm, with hail, much damage was done in this neighbourhood. Following the middle of August and during the earlier part of September ideal summer weather occurred with little rain, plentiful sunshine and mild, southerly winds. There was a recurrence of thundery conditions, with frequent rains and relatively high temperatures during the last two weeks of September and the early days of October. During the remainder of the autumn until the middle of December, the weather was unusually mild and open with abundant sunshine. The year concluded with a spell of exceptionally cold weather with north-easterly winds and the heaviest fall of snow recorded here for some years.

The total rainfall for the year was twenty-three inches. This was almost three inches less than the average annual rainfall here during the past twenty-three years. In general, the spring months were dry and the autumn months slightly wetter than usual. The year was the most sunny since 1933. The total hours of sunshine amounted to 1,621, 142 hours more than the 23 years' average here. The outstandingly sunny month was March with a total of 197 hours, almost 80 hours in excess of the average. Thus, if we except June, March was actually the sunniest month of the year and was the sunniest March recorded here since the station was established. April and October were also much sunnier than in recent years. Temperatures took a fairly normal course with the exception of a period during March, when they were much above the average, and November, when warm, close, but not particularly sunny weather occurred. Ground frosts were unusually prevalent during the late spring, no fewer than 15 being registered between 1st April and 10th May. Of these 6 were of exceptional severity.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1938.

	Temperature in Screen.					No. of Ground Frosts.	Rainfall.			Sunshine.			Soil Temperature.		
	Mean Maximum.	Mean Minimum.	Highest.	Lowest.	Mean.		Total in inches.	Heaviest fall in a day.	23 years' average.	Total hours.	Average per day.	23 years' average.	4 inches.	8 inches.	2 feet.
January ..	47·6	37·3	57	24	42·4	6	2·94	0·33	2·42	43·3	1·4	47·2	39·9	40·4	41·5
February ..	46·1	34·8	55	25	40·4	12	0·85	0·23	1·90	77·3	2·8	68·5	36·2	37·1	40·3
March ..	57·2	37·4	68	30	47·3	11	0·40	0·28	1·52	196·7	6·3	121·0	43·1	44·1	45·1
April ..	56·3	34·8	65	25	45·6	12	0·41	0·07	2·09	163·5	5·4	127·7	46·2	46·5	48·2
May ..	58·9	41·6	76	27	50·4	3	2·21	0·35	1·74	160·3	5·2	193·7	51·8	50·4	51·3
June ..	69·8	49·3	79	40	59·5	0	0·58	0·20	1·52	242·4	8·1	203·7	60·6	59·5	59·7
July ..	69·8	50·4	83	40	60·1	0	1·41	0·32	2·12	190·4	6·1	191·5	62·5	61·6	62·2
August ..	71·2	52·3	83	39	61·8	0	2·93	0·91	2·16	161·2	5·2	182·7	63·3	63·2	64·4
September ..	66·5	48·2	78	37	57·4	0	3·08	1·75	2·20	144·2	4·8	148·9	57·7	57·7	59·6
October ..	58·0	41·1	64	26	49·5	5	2·55	0·35	2·50	135·7	4·4	101·4	48·7	49·8	53·0
November ..	54·9	42·3	69	27	48·6	7	2·49	0·40	2·95	52·0	1·7	53·9	47·0	47·6	49·5
December ..	44·0	33·1	55	19	38·5	13	3·14	0·46	2·85	54·2	1·8	38·5	38·0	39·6	42·5





Diagrams showing Total Sunshine and Rainfall during 1938 as compared with 23 years' average.
Shaded portion 23 years' average.

PHYSIOLOGY

NOTE ON THE EFFECT OF THE VARIETY OF STOCK USED TO PROVIDE THE INTERMEDIATE STEM-PIECE IN SOME DOUBLE-WORKED APPLE TREES

By M. C. VYVYAN

Introduction.

It was shown by Knight (2) (3), that an additional piece of stock stem between scion and rootstock had some effect on tree performance, but less than that of the rootstock ; he (2) pointed out, however, that his results were not quite conclusive for various reasons ; in particular, since the two unions in his double-worked trees had been made in successive seasons, there was the possibility that the behaviour of the trees, in later years, might have been influenced by differences imparted to the rootstocks during the year when the intermediate stem-piece was functioning as a " first scion ". This ambiguity can be avoided by making the two unions in a single season, either by grafting the scion on to the intermediate stem-piece and the intermediate on to the rootstock in a single operation, or by the use of "budded grafts". The results of an experiment, where the double grafting method was used, have been described in a recent paper (4) ; they confirmed and extended those found by Knight. The trees, whose performance will be described here, were made by the " budded graft " method ; they were mentioned by Knight (2) and referred to in the recent paper (4), where it was stated that they would be described in a separate paper.

Material.

The trees were all of the same scion variety, Stirling Castle, and were all on the same rootstock, No. XII. In half the trees there was an intermediate piece of No. II stem between the scion and rootstock ; in the remaining trees there was a similar length of No. XII stem.

The trees were prepared by the Propagation Section as follows :—Buds of Stirling Castle were inserted high up on stems of No. II and No. XII in July, 1927, when these were still on their own roots; early the following spring, these budded stems were cut off, some distance below the buds, and grafted at about ground level on to the stems of rooted No. XII stocks. The piece of stem between the scion bud and the graft formed the intermediate stem-piece and care was taken to ensure that this was always of about the same length—25 cm.

The trees were left in the nursery rows and the maiden growth cut back hard at the end of the first season. In the spring of 1930, when they had completed their second year of growth, the trees were lifted, weighed and replanted 9 ft. apart, in a single row, arranged thus—ABBAAB etc., so as to permit their comparison in pairs. There were guard trees at each end of the row.

There were originally sixteen trees of each kind in the experiment but three of each had to be removed when the new Packing Shed was built in May, 1935 ; the guard tree was replaced. The results described here are based on the remaining twenty-six trees—thirteen of A. (II/XII) and thirteen of B. (XII/XII).

Cultural and pruning treatments were the same, as far as possible, for all trees, and the blossom buds were removed from all, each season, as soon as the trusses could be counted.

The experiment was concluded in the winter, 1937-8, when the trees had completed ten years' growth from the time of the insertion of the budded grafts and eight years in the experimental row. The trees were lifted in December, 1937, washed, cut up and weighed.

Results.

(1) *Wood Growth.* The wood growth, or summer length of new shoots, was determined before pruning every year, and the mean values are given in columns 1 and 2 of Table I. There are no records for the maiden year. The accumulative totals are shown in Fig. 1. Standard errors were worked out for the last three years, 1935-7, and for total wood growth summed to the end of 1936 and 1937 respectively ; these are given

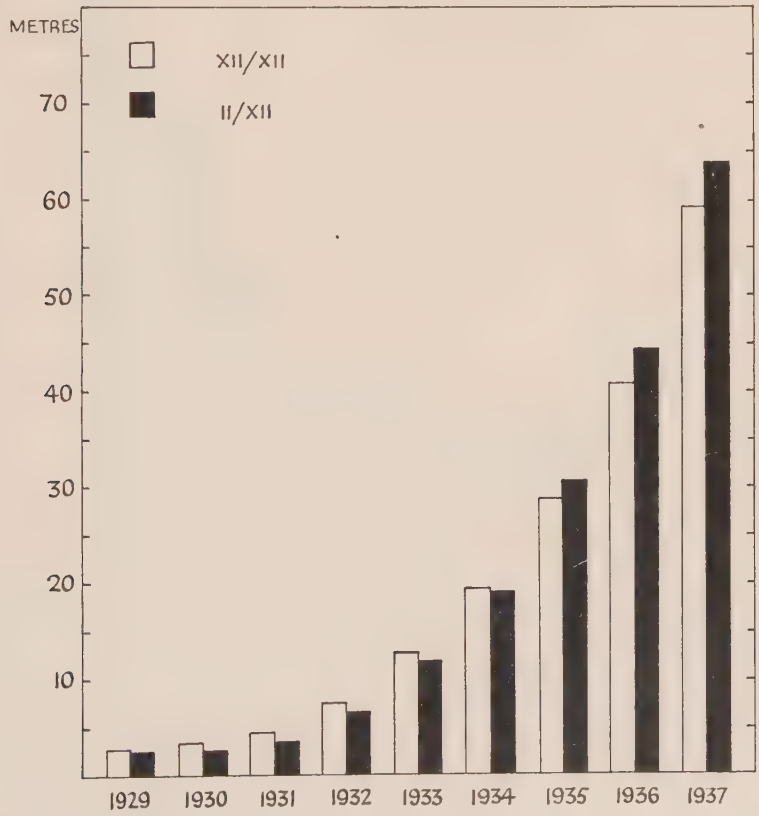


Fig. 1.

Wood growth, accumulative totals per tree from 1929 to 1937.

in Table II. The standard errors of the differences were determined by comparing the trees in pairs, —AB, BA, AB, etc.

The values for wood growth were slightly higher in later years in the II/XII trees, but the differences were not significant.

(2) *Fruit Buds.* The fruit buds formed each summer were estimated by counting the number of blossom trusses present the following spring ; those on the prunings were included. The numbers of terminal, axillary and spur trusses were counted separately, but have been summed together to give the mean values shown in columns 3 and 4 of

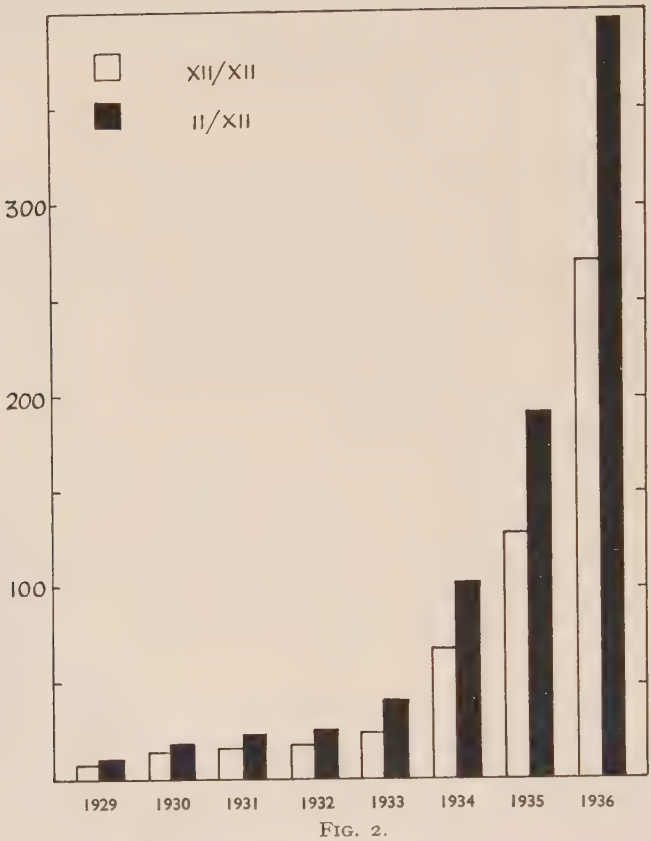


FIG. 2.
Number of Fruit buds, accumulative totals per tree from 1929 to 1936.

Table I. The accumulative totals are plotted in Fig. 2. No values are available for the season 1937, as the trees were dug up that December before the blossom trusses could be distinguished.

Standard error of the mean values for 1935 and 1936 and for the summed values to the end of 1936 are given in Table II.

From 1933 onwards the trees with an intermediate of No. II had more fruit buds than those with an intermediate of No. XII, but up to the end of 1935 the differences were not significant. In 1936, however, the differences became thoroughly significant.

(3) *Fruit Buds per Metre Wood.* The greater number of fruit buds on trees on No. II intermediate was due in part to the slightly greater wood growth on those trees.

To eliminate this effect of tree size, the values of fruit buds per metre wood growth have been determined for the years 1935 and 1936 and for the total fruit buds and total wood growth to the end of 1936 ; the mean values and standard errors are given in Table II.

The difference between the two sets of trees was not significant in 1935, but was quite significant in 1936.

(4) *Weight of Prunings.* The weights of prunings were recorded every year except in the maiden year and 1931. The mean values, given in columns 5 and 6 of Table I, closely parallel the corresponding values for wood growth, given in columns 1 and 2, showing that the degree of pruning was fairly uniform.

(5) *Cross Section of Trunk.* The diameter of the trunk was determined each year at two points ; one on the old maiden wood of the scion, the other on the intermediate piece of stem. Paint marks were made on the trunks to ensure that the measurements should be made at the same positions each year. Each measurement was made in two directions, North-South and East-West at each point, and the mean values converted to cross sections by use of Castle's Tables. The mean values for the cross sections of the scion portion of trunk are given in columns 7 and 8 of Table I, the corresponding values for the intermediate portion of the trunk are given in columns 9 and 10.

The values for the scion (Stirling Castle) were almost identical in the two sets of trees, though there is some indication that the trees on the No. II intermediate were gaining slightly in later years. The values for the intermediate were consistently lower when this was No. II than when it was No. XII. These facts are brought out diagrammatically in Fig. 3 which is based on mean diameters. Concentric circles have been drawn round these mean diameters to represent the cross section in successive years. Lines have been drawn to connect the points representing the annual values of the diameter of the scion (upper circles) with those for the intermediate (lower circles) to show the relative taper in the two kinds of tree and to reveal any change in taper from year to year.

The taper was greater in trees where the intermediate was No. XII, and neither set of trees showed any appreciable change in taper during the nine years of growth.

(6) *Weight of Trees.* The mean weight of the trees, when they were lifted from the nursery rows in the spring of 1930, are given in the top line of Table III ; the two mean values are almost identical. The mean weights of prunings removed at the time of transplanting are given in the second line, and the differences, or " pruned weights " are given in the third line. These represent the mean weights (W_0) of the trees at the beginning of their period of growth in the experimental row. The fourth line gives the mean weights of prunings removed during that period of growth ; the values for 1931 are not included, but inspection of the values for other years in Table I suggests that those for that year would have been somewhere between 10 and 20 grammes and therefore negligible.

The mean final weights of the trees, when lifted in December, 1937, are given in the fifth line of Table III, and have been combined with the mean weight of prunings in the sixth line. If the mean pruned weights at transplanting (W_0) are deducted from these values, the remainder represents the total increment in stem and root weight during the experimental period ; these are given in the seventh line.

The values in most cases were slightly larger for the II–XII trees, but in no case was the difference significant.

(7) *Rate of Growth.* If the final weight (W_1) is divided by the initial weight (W_0), the resulting quotient W_1/W_0 is a convenient measure of the rate of growth—though

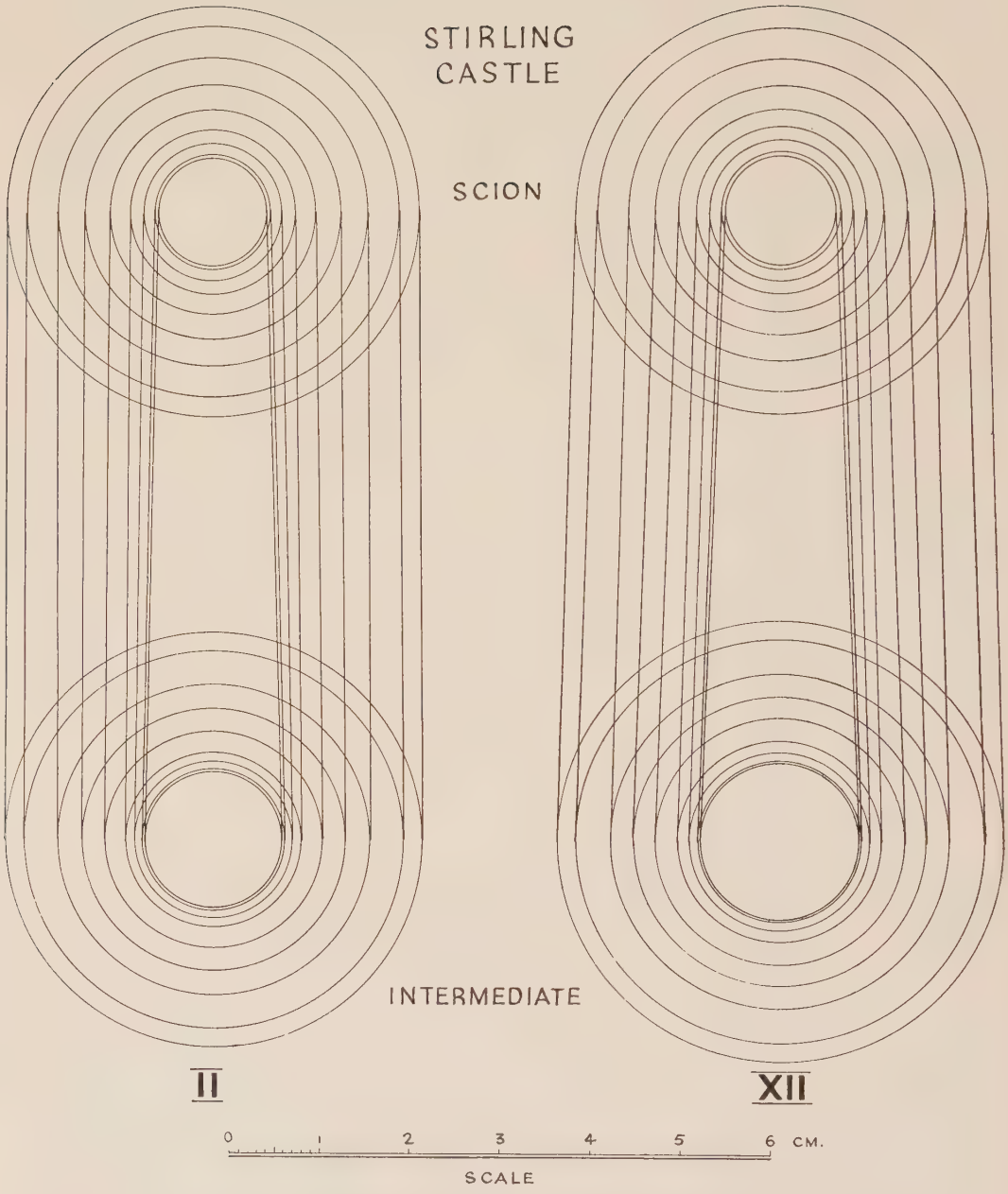


Fig. 3.

Cross section of Trunk in successive years from 1929 (innermost circles) to 1937 (outermost circles). Upper figures represent scion Stirling Castle, lower figures the intermediate stem piece No. II or No. XII. Vertical lines show relative taper.

for some purposes the natural logarithms of these quotients must be used. The mean values for these quotients are given in the bottom line of Table III.

The II/XII trees increased about seventeen-fold during the experimental period, the XII/XII trees about fifteen-fold, but this slight difference was not significant.

(8) *Relative Weights of Stems and Roots, Trunk and Branches.* When lifted in 1937, the trees were weighed before and after the removal of the roots, and after the removal of the branches. The weights of roots and branches were got by the differences. All the final weights were taken in pounds to the nearest 1/10th of a pound, but the values have been converted into grammes for comparison with earlier weights.

The roots were cut off as near the trunk as possible, and the below-ground portion of stock stem included in the weight of " trunk ".

The mean weights of stem and roots are given in the top two lines of Table IV ; the stem has been further subdivided into trunk and branches in the third and fourth lines. The values for each tree were also reduced to percentages of total weight, and these are given in the lower part of the table. Finally the ratio branch/trunk was worked out for every tree and the mean values are given in the bottom line of the table.

It will be seen that the slight differences between the two kinds of tree in no case approach significance.

(9) *Condition of the Unions.* The upper or bud union could easily be distinguished in both sets of trees when they were lifted in 1937 ; in the II/XII trees there was a considerable swelling of scion wood just above it, but in the XII/XII trees there was no trace of a swelling. The position of the lower, or graft, union could be just discerned in the II/XII trees, but no outward trace of it could be found in the XII/XII trees.

Blair (1) reports similar results for trees of Bramley's Seedling double-worked on French crab with intermediates of Nos. II and XII. The trees were " almost identical in size and weight " on the two intermediates but the No. II intermediate " was clearly defined as a restricted portion of the main stem ".

Table I.

Mean Annual Values of Wood Growth, Number of Fruit Buds, Weight of Prunings, and Cross Sections of Scion and " Intermediate Stem-Piece " Portions of Trunk.

Year.	Mean Wood Growth.		Mean Number of Fruit Buds.		Mean Weight of Prunings.		Mean Cross Section of Scion.		Mean Cross Section of Intermediate.	
	II/XII.	XII/XII.	II/XII.	XII/XII.	II/XII.	XII/XII.	II/XII.	XII/XII.	II/XII.	XII/XII.
	cm.	cm.			gm.	gm.	sq. cm.	sq. cm.	sq. cm.	sq. cm.
1929	251	289	10·5	8·2	34·6	38·0	1·193	1·161	1·793	2·324
1930	24	51	8·7	6·3	2·5	6·6	1·280	1·274	1·852	2·487
1931	94	91	4·6	2·3	?	?	1·815	1·854	2·388	3·132
1932	275	298	1·7	1·7	44·8	46·3	2·635	2·622	2·985	3·962
1933	546	546	15·4	6·2	85·8	83·3	4·083	4·044	4·589	5·902
1934	706	655	61·8	44·0	98·7	80·7	6·270	5·999	6·924	8·280
1935	1,154	950	88·2	60·2	184·7	163·9	9·385	8·925	9·507	11·076
1936	1,365	1,203	205·0	140·8	251·3	219·8	13·542	12·877	14·275	16·164
1937	1,949	1,814	?	?	—	—	16·536	15·895	17·025	19·243

Table II.

Annual Values and Accumulative Totals of Wood Growth and Fruit Buds for Later Years, and Fruit Buds Per Metre Wood Growth. The differences in heavy type were thoroughly significant.

	II/XII.		XII/XII.		II/XII—XII/XII.	
	Mean.	S.E.	Mean.	S.E.	Mean.	S.E.
Annual Wood Growth, 1935	1154	99·0	950	75·0	+ 204	112·2
Annual Wood Growth, 1936	1365	126·3	1203	64·5	+ 162	127·2
Annual Wood Growth, 1937	1949	156·5	1814	102·6	+ 135	183·3
Total Wood Growth to end of 1936 ..	4416	302·2	4082	241·7	+ 334	376·8
Total Wood Growth to end of 1937 ..	6365	451·7	5896	333·7	+ 469	549·5
Annual Fruit Buds, 1935	88·2	16·47	60·2	9·02	+28·0	16·76
Annual Fruit Buds, 1936	205·0	12·85	140·8	7·95	+64·2	13·40
Total Fruit Buds to end of 1936 ..	395·9	31·12	269·7	13·88	**+126·2**	29·08
Annual Fruit Buds per metre Annual Wood Growth (1935 ..	7·75	1·318	5·89	1·084	+1·86	1·647
Annual Wood Growth (1936 ..	16·05	1·191	11·94	·711	**+4·11**	1·226
Total Fruit Buds per metre to Total Wood Growth to end of 1936 ..	9·22	2·382	6·81	1·502	+2·41	2·828

Table III.

Mean Weight of Trees at Lifting From Nursery Rows in Winter, 1929-30, Their Pruned Weight at Replanting in Experimental Row. Also Final Weight at Lifting in 1937, and Summed Weights of Prunings During Experimental Periods. None of the differences between the II/XII and XII/XII trees are statistically significant.

	II/XII.		XII/XII.		II/XII—XII/XII.	
	Mean.	S.E.	Mean.	S.E.	Mean.	S.E.
(1) Weight at Lifting, April, 1930 ..	375·4	25·86	375·1	15·81		
(2) Prunings, April, 1930	34·6	3·65	38·0	3·61	− 3·4	4·54
(3) Pruned Weight (W_0), April, 1930 ..	340·8	22·39	337·1	13·54	+ 3·7	26·48
(4) Prunings, 1930-6, summed weight	667·9	55·77	600·7	46·22	+ 67·2	58·80
(5) Final Weight at Lifting (W_1), 1937	5673·4	324·93	5160·4	270·14	+513·0	407·47
(6) Final Weight and Prunings (4)+(5)	5341·2	369·85	5761·1	309·38	+580·2	462·20
(7) Increment (6) + (3)	6000·5	365·38	5424·0	300·24	+576·5	454·05
(8) W_1/W_0 (5)/(3)	17·35	1·495	15·33	·585	+ 2·02	1·604

Table IV.

Actual and Percentage Weights of Stem and Root and of Trunk and Branches. Also Ratio of Branch Weight to Trunk Weight. None of the differences between the II/XII and XII/XII trees are significant.

	II/XII.		XII/XII.		II/XII=XII/XII.	
	Mean.	S.E.	Mean.	S.E.	Mean.	S.E.
	gm.		gm.		gm.	
Weight of Stem	4023	229·7	3757	2004	+366·5	289·3
Weight of Root	1650	102·0	1504	86·7	+146·5	136·1
Weight of Trunk	1916	86·1	1821	82·8	+ 94·4	118·4
Weight of Branches ..	2107	149·7	1835	125·6	+272·2	180·0
	%		%		%	
% Weight of Stem ..	71·1	·615	70·7	·812	+ ·38	1·152
% Weight of Root ..	28·9	·615	29·3	·812	− ·38	1·152
% Weight of Trunk ..	34·27	·943	35·53	·665	−1·246	1·1131
% Weight of Branches ..	36·75	·703	35·28	·818	+1·477	0·8510
Branch/Trunk	1·088	·0447	1·001	0·372	·0869	·0474

Discussion.

The two sets of trees compared were of the same variety, Stirling Castle, on the same rootstock (No. XII), and differed only in the nature of the intermediate stem-piece inserted between the stem of the scion and that of the rootstock, and in the nature of the unions above and below this stem-piece. In the one set of trees the stem-piece was of No. II stock and the unions therefore Stirling Castle/No. II and No.II/No. XII respectively. In the other the stem-piece was of No. XII stock and the unions Stirling Castle/No. XII and No. XII/No. XII respectively.

When the trees were lifted in 1937, the two kinds could easily be told apart by the taper of the upper part of the trunks (this was less in the II/XII trees), and by the swelling above the upper union in the II/XII trees. There was no obvious difference in average tree size.

The results of the annual and final measurements made on the trees, and described in the last section, show that the nature of the intermediate had no significant effect on the vigour of the trees, whether this is expressed as wood growth, final weight or rate of growth. Neither had it any significant effect on the relative weights of stem and root or trunk and branches.

The number of fruit buds per tree and per metre wood became progressively greater on the II/XII trees than on the XII/XII trees, and in 1936 the differences had become thoroughly significant.

Thus the insertion of the less vigorous stem of No. II, between the very vigorous rootstock No. XII and the scion, pushed up fruit bud formation without reducing vigour, but it is doubtful whether the slight increase in fruit bud formation would justify the expense of making the more complicated kind of tree.

Acknowledgements.

The experiment was planned by Dr. Knight, and the trees were prepared by the Propagation Section. Until Dr. Knight's death early in 1935, the experiment was

conducted sometimes by him and sometimes by the present writer. Dr. H. L. Pearse was responsible for the trees in 1936 and the present writer had charge of them in 1935 and 1937. Most of the routine annual wood measurements and fruit bud counts were made by the recording staff of the Pomology Section.

Summary.

(1) Apple trees were double-worked in a single season by the insertion of scion buds high up on stems in July, and the grafting of these stems on to rootstocks the following winter.

(2) The scion was Stirling Castle in all trees and the rootstock No. XII. The intermediate was No. II in one set of trees and No. XII in the other. The rootstock included a piece of stem as well as roots.

(3) After ten years there was no difference in cross section of scion in the two sets of trees but that of the intermediate was less in the II/XII trees. There was also a swelling above the upper union in these trees, and none in the XII/XII trees.

(4) There was no significant difference in wood growth, final weight, or rate of growth between the two sets of trees, or in the relative weights of stem and root or trunk and branches.

(5) Trees with a No. II intermediate produced progressively more fruit buds than those with No. XII intermediate and by 1936 the number per tree and per metre wood had become significantly greater.

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EXPERIMENTS WITH GROWTH CONTROLLING SUBSTANCES

II. RESPONSE OF FRUIT TREE CUTTINGS TO TREATMENT WITH SYNTHETIC ROOT-FORMING SUBSTANCES

By H. L. PEARSE

Introduction.

In 1937, Pearse and Garner (1) reported preliminary experiments which showed that suitable treatment with α-naphthalene acetic acid greatly stimulated the rooting of softwood cuttings of certain plum and pear rootstocks, and it was then pointed out that, apart from the various external factors, such as concentration of solution used for treatment, and conditions during treatment and rooting period, the physiological state of the cuttings themselves is a most important factor in governing the rooting response. During the 1938 season many thousands of cuttings of different varieties of pear, quince, apple, plum and cherry rootstocks were treated with α-naphthalene acetic acid, and indolebutyric acid with the object of obtaining further knowledge of the factors governing the rooting response. The number of varieties tested was restricted so that, with the amount of propagating space at present available, a number of tests could be carried out on the same variety during the season ; the results of these tests are reported in this article.

Preparation of the Test Solution.

Indolebutyric acid and α-naphthalene acetic acid* are not readily soluble in water, so the solutions were prepared by dissolving the solids in 95 per cent. alcohol, and then making up to the required volume with distilled water. The ultimate amount of alcohol in the test solutions was never more than one part in a thousand.

Treatment of the Cuttings.

The treatment of the cuttings was similar to that worked out at the Boyce Thompson Institute by Hitchcock and Zimmerman (2). The cuttings were freshly prepared, and after removing a few of the lower leaves, the basal ends of the cuttings were immersed to a depth of about one inch in the test solutions. The concentrations used were within the range 5 to 80 p.p.m., and, as space was restricted, only one immersion time could be used ; a twenty-four hour period was therefore selected as being the most convenient time of treatment, and during the treatment period the cuttings were placed in a cool room shaded from direct sunlight.

* The sample of indolebutyric acid was kindly supplied by Messrs. May & Baker, Dagenham, and the α-naphthalene acetic acid was obtained from the British Drug Houses.

Rooting Conditions.

After treatment the immersed ends of the cuttings were rinsed in tap water to remove any surplus solution, and they were then set in pure Bedfordshire sand in propagating frames with bottom heat. About ¾ inch of the base of the cuttings was covered by the sand. The temperature of the rooting medium was not strictly controlled but varied between 65° F. and 75° F. with the air temperature in the frames about 5° F. lower. During bright sunshine the frames, which were in a glass house, were covered with one thickness of cheese cloth, and the glass house itself was coated with the proprietary wash "Summer Cloud". The cuttings were lightly watered night and morning to obtain a sufficiently high humidity to prevent the cuttings flagging without waterlogging the rooting medium.

Source of Material.

All the cuttings used in these tests were taken from material growing in the open and were not from specially potted greenhouse plants. The cuttings were usually tips about four inches long, and were obtained from the various sources from which quantities were available, such as bedded rootstocks, layer-bed shoots, and old established trees. The majority of the species tested are considered moderately or extremely difficult to root from softwood cuttings especially when the cuttings are taken from outdoor material, and therefore, where possible, several tests were made on the same variety at different periods during the season.

Tests with Vitamin B_1.

Went, Bonner, and Warner (3) have suggested that the synthetic root-forming substances are mainly effective in causing the formation of root initials, and that in some difficult species these root initials will fail to grow out unless supplied with Vitamin B_1; they therefore recommended the application of a solution of Vitamin B_1, about ten days after the treatment with the root-forming substance. Accordingly a number of tests have been carried out giving treatments with Vitamin B_1, at a concentration of 1 mg. per litre from ten to twelve days after planting.

Results.

The results obtained from these tests are presented in tabular form. In instances where an increase in rooting was obtained with several different concentrations the optimum treatment is given, and where no response occurred the range of treatments tried is indicated. In every treatment the number of cuttings used was ten and the figures given for number of cuttings rooted are out of ten. Percentages are not given as with small numbers of cuttings such figures have little significance.

Pear Cuttings.

Varieties tested. Malling "Free" Pear Rootstocks Nos. C2, C3, C4 and B2.

Softwood pear cuttings responded very favourably to treatment, and, with the exception of very soft cuttings of C4 taken early in the season when still in active growth, a good response was obtained with all the varieties tested. Rooting was mainly from the basal callus; untreated cuttings usually callused well; but with the exception of one cutting of C2 no rooting occurred during the experimental period.

TABLE I.

RESPONSE OF PEAR SOFTWOOD CUTTINGS TO TREATMENT WITH α-NAPHTHALENE ACETIC ACID AND INDOLEBUTYRIC ACID.

Variety.	Source of Cuttings.	Condition of Cuttings.	Date Treated.	Rooting Period Days.	Best Treatments p.p.m. 24 hrs.	Treated No. Rooted.	Control No. Rooted.
Rootstock Malling C4	12-year-old tree	In active growth.	9th May	26	*A 10-80	0	0
,,	,,	,,	,,	,,	B 10-80	0	0
,,	,,	Growth just stopped.	1st June.	35	A 20	5	0
,,	,,	,,	,,	,,	B 40	6	0
,,	,,	Growth stopped.	8th July.	54	A 40	8	0
,,	,,	,,	,,	,,	B 40	7	0
Rootstock Malling C2.	,,	In active growth.	9th May.	26	A 20	6	0
,,	,,	,,	,,	,,	B 20	7	1
,,	,,	Growth stopped.	7th July.	53	A 30	6	0
,,	,,	,,	,,	,,	B 30	8	0
Rootstock Malling C3.	,,	,,	28th July.	44	A 40	5	0
,,	,,	,,	,,	,,	B 40	6	0
Rootstock Malling B2.	,,	,,	,,	,,	A 20	7	0
,,	,,	,,	,,	,,	B 20	9	0

* A=alpha-naphthalene acetic acid. B=Indolebutyric acid.

In tables I-V where no treatment was effective the range of treatments is given.

Quince Cuttings.

Varieties tested. Malling Rootstocks Quince A and Quince C.

TABLE II.

RESPONSE OF QUINCE SOFTWOOD CUTTINGS TO TREATMENT WITH α-NAPHTHALENE ACETIC ACID AND INDOLEBUTYRIC ACID.

Variety.	Source of Cuttings.	Condition of Cuttings.	Date Treated.	Rooting Period Days.	Best Treatments p.p.m. 24 hrs.	Treated No. Rooted.	Control No. Rooted.
Rootstock Quince A.	Bedded rootstocks	In active growth.	6th May.	21	* A20	8	0
,,	,,	,,	,,	,,	B 20	9	0
,,	,,	,,	1st June.	29	A 5-40	0	0
,,	,,	,,	,,	,,	B 5-40	0	0
,,	,,	Growth stopped.	6th July.	45	A 15	6	3
,,	,,	,,	,,	,,	B 15	7	3
Rootstock Quince C.	,,	In active growth.	6th May.	21	A 10	1	0
,,	,,	,,	,,	,,	B 20	2	0
,,	,,	,,	1st June.	29	A 5-40	0	0
,,	,,	,,	,,	,,	B 5-40	0	0

* A=alpha-naphthalene acetic acid. B=indolebutyric acid.

Quite soft cuttings of Quince A in active growth, taken in May, rooted well after treatment, while older cuttings still in growth taken early in June did not respond; a moderate response was also obtained with cuttings taken in July when growth had stopped, and several of the control cuttings also rooted at this later date. Quince C cuttings gave little response but the material available was rather poor, and further tests are needed.

Apple Cuttings.

Varieties tested. Malling Rootstocks, Nos. I, II and IX, and the scion variety Bramley's Seedling.

TABLE III.

RESPONSE OF APPLE SOFTWOOD CUTTINGS TO TREATMENT WITH α-NAPHTHALENE ACETIC ACID AND INDOLEBUTYRIC ACID.

Variety.	Source of Cuttings.	Condition of Cuttings.	Date Treated.	Rooting Period Days.	Best Treatments p.p.m. 24 hrs.	Treated No. Rooted.	Control No. Rooted.
Rootstock Malling No. I.	Bedded rootstocks	In active growth.	12th May.	24	*A 20	1	0
,,	,,	,,	,,	,,	B 20	1	0
,,	Stoolbed shoots.	,,	,,	,,	A 20	8	0
,,	,,	,,	,,	,,	B 20	10	0
,,	Bedded rootstocks.	Growth stopped.	30th June.	,,	A 20	2	0
,,	,,	,,	,,	,,	B 20	3	0
,,	Stoolbed shoots.	,,	,,	,,	A 20	9	0
,,	,,	,,	,,	,,	B 20	10	0
Rootstock Malling No. IX.	Bedded rootstocks	In active growth.	11th May.	,,	A 5	3	0
,,	,,	,,	,,	,,	B 10	2	0
,,	,,	Growth stopped.	7th July.	,,	A 5-40	0	0
,,	,,	,,	,,	,,	B 5-40	0	0
Rootstock Malling No. II.	,,	,,	28th July.	,,	A 5-40	0	0
,,	,,	,,	,,	,,	B 5-40	0	0
Scion variety Bramley's Seedling.	Established trees.	,,	7th July.	50	A 15	4	0
,,	,,	,,	,,	,,	B 15	5	0

*A = alpha-naphthalene acetic acid. B = indolebutyric acid.

Malling No. I Rootstock. Cuttings taken from stoolbed shoots rooted well after treatment both when in active growth and when the terminal bud had formed, whereas apparently similar cuttings taken from bedded stocks gave a very poor response; all the controls failed to root. Fig. 1.

Malling No. II Rootstock. Only one series of cuttings were treated and no rooting was obtained, the cuttings rapidly rotted in the frames.

Malling No. IX Rootstock. A few cuttings, taken while in active growth on 11th May, rooted after treatment, while cuttings treated on 7th July not actively growing quickly rotted.

Scion Variety. Bramley's Seedling. Several cuttings from shoots with the terminal bud formed rooted well after treatment.

Plum Cuttings.

Varieties tested. Malling Rootstocks, Myrobolan B, Brompton, Common Mussel and Pershore ; scion variety Victoria.

TABLE IV.

RESPONSE OF PLUM SOFTWOOD CUTTINGS TO TREATMENT WITH α-NAPHTHALENE ACETIC ACID AND INDOLEBUTYRIC ACID.

Variety.	Source of Cuttings.	Condition of Cuttings.	Date Treated.	Rooting Period Days.	Best Treatments p.p.m. 24 hrs.	Treated No. Rooted.	Control No. Rooted.
Rootstock Myrobolan B.	Bedded Stocks.	In active growth.	19th April.	24	*A 5-80	0	1
,,	,,	,,	,,	,,	B 5-80	0	0
,,	,,	Growth stopped.	30th May.	23	A 10	10	9
,,	,,	,,	,,	,,	B 20	10	8
Rootstock Brompton.	Layer bed shoots.	In active growth.	16th May.	18	A 5-80	0	0
,,	,,	,,	,,	,,	B 5-80	0	0
,,	,,	Growth stopped.	28th July.	47	A 20	3	1
,,	,,	,,	,,	,,	B 10 & 20	8	1
Rootstock Common Mussel.	,,	In active growth.	16th May.	18	A 5-80	0	0
,,	,,	,,	,,	,,	B 5-80	0	0
Rootstock Pershore.	Bedded rootstocks.	,,	12th May.	14	A 5-80	0	0
,,	,,	,,	,,	,,	B 5-80	0	0
,,	,,	,,	20th June.	,,	A 5-80	0	0
,,	,,	,,	,,	,,	B 5-80	0	0
,,	,,	Growth stopped.	28th July.	47	A 20	1	0
,,	,,	,,	,,	,,	B 20	3	0
Scion variety Victoria.	Established trees.	,,	6th July.	50	A 15	8	0
,,	,,	,,	,,	,,	B 15	7	0

*A=alpha-naphthalene acetic acid. B=indolebutyric acid.

Plum Rootstock, Myrobolan B. Very young cuttings in active growth treated on 19th April did not root and all the cuttings rotted ; harder cuttings taken when growth had stopped on 30th May rooted well at optimum treatments, and the majority of the control cuttings taken at this date also rooted. The number of roots per cutting was, however, greatly increased by treatment.

Plum Rootstock, Brompton. Very soft tips in active growth treated on 16th May quickly rotted, and treatment only accelerated rotting; however, tips with the terminal bud formed treated on 28th July, gave a good response, treatments with indolebutryric acid at 10 and 20 p.p.m. being especially effective.

Plum Rootstock, Common Mussel. Only soft tips in active growth were treated, on 16th May, and these quickly rotted after planting.

Plum Rootstock, Pershore. Very soft tips in active growth taken on 12th May and harder cuttings still in growth treated on 30th June rotted; but a few cuttings treated on 28th July rooted.

Scion Variety, Victoria. Cuttings from large established trees made from the tips of shoots which had stopped growth, and treated on 6th July, rooted well, while control cuttings failed to root.

Cherry Cuttings.

Varieties tested: Malling Rootstocks. $F\frac{251}{1}$, $F\frac{251}{2}$, $F\frac{251}{3}$ and $F\frac{12}{1}$

TABLE V.

RESPONSE OF CHERRY SOFTWOOD CUTTINGS TO TREATMENT WITH INDOLEBUTYRIC ACID.

Variety.	Source of Cuttings.	Condition of Cuttings.	Date Treated.	Rooting Period. Days.	Best Treatments p.p.m. 24 hrs.	Treated No. Rooted.	Control No. Rooted.
Rootstock $F\frac{251}{1}$	Established trees.	In active growth.	3rd June.	14	*B 5-80	0	0
,,	,,	Growth stopped.	30th June.	28	B 15	9	5
,,	,,	,,	5th Aug.	42	B 20	2	0
Rootstock $F\frac{251}{2}$	,,	In active growth.	3rd June.	14	B 10	6	2
,,	,,	Growth stopped.	30th June.	28	B 15	10	9
,,	,,	,,	5th Aug.	42	B 5-20	0	0
Rootstock $F\frac{251}{3}$	,,	In active growth.	3rd June.	14	B 20	3	0
,,	,,	Growth stopped.	30th June.	28	B 15	9	4
,,	,,	,,	5th Aug.	42	B 20	2	0
Rootstock $F\frac{12}{1}$	,,	In active growth.	3rd June.	14	B 5-80	0	0
,,	,,	Growth stopped.	30th June.	28	B 15	6	0
,,	,,	,,	5th Aug.	42	B 10	9	0

*B=indolebutyric acid.

Cuttings of all the varieties of cherry rootstocks tested responded well to treatment with indolebutyric acid when suitable material was used. In general cuttings in which

growth had stopped, rooted best. $F\frac{251}{1}$, $F\frac{251}{2}$, and $F\frac{251}{3}$ do root fairly readily without treatment with this type of material, and the maximum response to treatment was obtained when untreated cuttings also showed some rooting. Root formation was accelerated, however, and the number of roots produced was increased by treatment. $F\frac{12}{1}$ responded well to treatment, while control cuttings callused but did not root, Fig. 2.

Treatment with Vitamin B_1 in Addition.

TABLE VI.

THE EFFECT OF TREATING CUTTINGS WITH A SOLUTION OF VITAMIN B_1 AT A CONCENTRATION OF 1 MG. PER LITRE 10-12 DAYS AFTER THE TREATMENT WITH ROOT-FORMING SOLUTIONS.

Variety.	Source of Cuttings.	Condition of Cuttings.	Date Treated.	Treatment.	No. Rooted.	+ Vit. B1 No. Rooted.	Control No. Rooted.
Pear Rootstock C4.	12-year-old tree.	Growth stopped.	6th June.	*A 20	5	2	0
,,	,,	,,	,,	B 40	6	4	0
Apple Rootstock No. I.	Bedded rootstocks.	,,	30th June.	A 20	2	1	0
,,	Stoolbed shoots.	,,	,,	A 20	9	5	0
,,	,,	,,	,,	B 20	10	7	0
Plum Rootstock Myrobolan B.	Bedded rootstocks.	,,	30th May.	A 10	10	8	9
,,	,,	,,	,,	B 20	10	9	8
Cherry Rootstocks $F\frac{251}{2}$	Established trees.	In active growth.	3rd June.	B 10	6	3	2
$F\frac{251}{3}$	,,	,,	,,	B 20	3	0	0

*A=alpha-naphthalene acetic acid. B=indolebutyric acid.

It is seen from Table VI that a subsequent treatment with Vitamin B_1 did not increase the number of cuttings rooting in any of the varieties tested; in fact in all varieties there was a slight reduction which may have been due to the disturbance caused by the removal of the cuttings from the frames for the treatment and replanting. It was noticed, however, that after potting on from the frames, cuttings which had received the Vitamin B_1 tended to grow more vigorously.

GENERAL CONCLUSIONS.

These tests have shown that, besides those factors which are well known to affect the response of cuttings of any species or variety to treatment with synthetic root-forming substances (concentration of solution, time of immersion, conditions during the treatment period and conditions during the rooting period), the physiological

condition and the source of origin are of utmost importance. Thus it has been shown that with suitable material softwood cuttings of the majority of even the most difficult varieties will root up to 60 per cent. or over after suitable treatments with indolebutyric acid or α-naphthalene acetic acid.

The Physiological Condition of the Cuttings.

(*a*) With some varieties cuttings taken while the shoots were still in active growth rooted well after treatment, e.g. Pear Rootstock C2, Quince A, Apple Rootstock No. I. from stool bed shoots.

(*b*) Cuttings of some varieties responded well both when the shoots were in active growth, and also when growth had stopped, e.g. Pear Rootstock C2, Apple No. I. from stool-bed shoots.

(*c*) Cuttings of other varieties only responded well when taken after growth had stopped. Those of this class were by far the most numerous, e.g. Pear Rootstock C4, Plum Rootstocks, Myrobolan B, Brompton and Pershore, Cherry Rootstocks F $\frac{251}{1}$, F $\frac{251}{3}$, F $\frac{251}{3}$, F $\frac{12}{1}$.

(*d*) Very few varieties gave a better response from young cuttings taken in active growth than with older cuttings taken when growth had stopped, e.g. Quince A and Quince C.

The Source of the Material.

Cuttings of apple rootstocks No. I taken from stool-bed shoots responded very well to treatment, while cuttings taken from bedded stocks gave a very poor response, although in external appearance they appeared very similar. In many cases cuttings taken from old established trees rooted well after treatment, e.g. Pear Rootstocks C2, C3, C4, and B2; Apple scion variety Bramley's Seedling; Plum scion variety Victoria; Cherry Rootstocks F $\frac{251}{1}$, F $\frac{251}{2}$ and F $\frac{12}{1}$.

Type of Root System Produced after Treatment.

With many varieties of cuttings after treatment with either indolebutyric acid or α-naphthalene acetic acid, roots were produced not only from the basal callus, but also from the stem above. In general there has been a marked difference in the type of root system produced; with indolebutyric acid a finely branched fibrous root system is formed, while with α-naphthalene acetic acid the roots are usually thick and fleshy with few branches, and are easily broken when handled. In consequence the former type is much more easily transplanted from the frames without damage (Figs. 3 and 4). Treated cuttings grew on quite normally after removal from the frames.

Discussion.

In most cases where cuttings of any variety were successfully rooted after treatment the first effect was a swelling of the basal end of the cutting, usually followed by a splitting of the epidermis in some cases for an inch or more upwards from the base.

In every case where this response was noted after treatment the cuttings subsequently rooted. This effect was noted with the very few cuttings of the extremely difficult variety of plum rootstock Pershore which were successfully rooted, and cuttings which failed to root never showed this stimulation. It thus appears evident that a large number of the varieties which are very difficult to root will root fairly readily after a suitable treatment provided the right type of material is treated. The dependence of the response on the appropriate condition of the cuttings seems to point to some factor which controls root-formation after treatment. What this limiting factor is, is at present obscure, and further work will be carried out with the object of elucidating its nature, and determining the factors which influence its presence in the cuttings.

Hardwood Cuttings.

While the results obtained with softwood cuttings are interesting from the physiological standpoint, and may be of use where small quantities of material are required rapidly, they are of limited application for the raising of commercial rootstocks. Of the methods of propagation the most satisfactory would be that of hardwood stem cuttings; it has the advantage that the material required is easily obtained, and the area occupied by stem cuttings is, even in extreme cases, not greater than that required by layers and stools. Further, hardwood stem cuttings require less attention after planting than either layers, stools or softwood cuttings.

The usual procedure is to take, early in October, shoots of medium vigour of the current year's growth which are cut to a length of some 9 inches, the apical 4 inches or so of unripened stem being discarded. The basal cut is made just below a node and the cuttings are planted as soon as possible. They are planted about 3 inches apart in rows which are about 15 inches from each other, leaving about 1 inch of each cutting above ground level.

In an experiment including three varieties of plum rootstock, Myrobolan B, Brompton and Pershore, cuttings were planted in the autumn of 1937 after treatment with indolebutyric acid and α-naphthalene acid at concentrations from 5 to 160 p.p.m. Two hundred cuttings were included in each treatment and in no instance was the percentage of cuttings rooting significantly increased by the treatment. Further work is now in progress with the object of discovering a suitable technique for the treatment of hardwood fruit tree cuttings.

Summary.

1. Numerous tests with softwood cuttings of several varieties of pear, quince, apple, plum and cherry, have shown that with suitable material root formation is accelerated and increased by treatment with indolebutyric acid and α-naphthalene acetic acid.

2. The importance of the selection of the material to be used as cuttings has been clearly evidenced; thus the condition of the parent shoots whether growing or with growth stopped, and the source, such as established trees or bedded stocks, are factors which play a great part in governing the rooting response obtained after treatment.

3. In general indolebutyric acid has caused the production of a more fibrous root system than α-naphthalene acetic acid.

4. Subsequent treatment with Vitamin B_1 did not increase the number of cuttings rooting, but the cuttings so treated grew on more vigorously after removal from the frames.

5. No marked stimulation has yet been obtained from the treatment of hardwood cuttings in the autumn.

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(2) Hitchcock, A. E. and Zimmerman, P. W. "Effect of growth substances on the rooting response of cuttings." Contrib. Boyce Thompson Inst., 1936, **8**, 63-79.

(3) Went, F. W., Bonner, J. and Warner, G. C. "Aneurin and the rooting of cuttings." Science, 1938, **87**, 170-1.

FIG. 1.

Malling Apple Rootstock No. I.

Top row. Cuttings from bedded stocks treated with indolebutyric acid 20 p.p.m. for 24 hours.

Middle. Cuttings from stool bed shoots treated with distilled water.

Bottom. Cuttings from stool bed shoots treated with indolebutyric acid 20 p.p.m. for 24 hours.

Cuttings treated 12th May. Photographed 24 days later.

FIG. 2.

Cherry Rootstock. $F\frac{1}{1}^{2}$.

Above. Treated with distilled water, 24 hrs.

Below. Indolebutyric acid 10 p.p.m., 24 hrs.

Cuttings treated 5th August. Photographed 42 days later.

FIG. 3.
Quince A.
Top. Distilled water for 24 hrs.
Bottom. Indolebutyric acid 20 p.p.m. for 24 hrs.
Cuttings treated 6th May. Photographed 21 days later.

FIG. 4.
Quince A.
Top. Distilled water 24 hrs.
Bottom. α-naphthalene acetic acid 20 p.p.m. for 24 hrs.
Cuttings treated 6th May. Photographed 21 days later.

MYCOLOGY AND BACTERIOLOGY

NOTES ON PLANT DISEASES IN 1938

By H. WORMALD

Non-Parasitic Disorders.

The most serious meteorological factor adversely affecting the fruit crop in 1938 was the severe and prolonged frosts during April. Preceding weeks had been exceptionally mild for early spring, and fruit trees were in bloom much earlier than usual, so that the April frosts were particularly destructive. The early condition of the trees and the delay in development during the actual blossoming period affected also the spraying operations, and the control of scab at this stage was less effective than in other years (see under Apple and Pear Scab).

On 12th August a severe hailstorm, with thunder and lightning, was experienced at East Malling and caused damage to the comparatively few fruits left after the frost. Apples were deeply pitted and where the skin was ruptured the Brown Rot fungus entered and caused further damage.

Functional diseases of apples, such as Bitter Pit and Lenticel Spotting, were again prevalent in 1938, probably as a result of the rather long period of dry weather during early summer, followed by heavy rains in September.

In December specimens were received showing Papery Bark cankers around pruning cuts which had been made on cordon trees of Cox's Orange Pippin. No parasite could be found in the affected bark and it was concluded that the papery bark condition was a direct result of pruning which had been carried out at an unsuitable time. It was ascertained that the grower had omitted the ordinary summer pruning, and then began to prune the trees during a rainy period in September; it was only on these September pruned trees that the trouble was serious.

The probable explanation of these papery bark cankers is, that the heavy rains following the summer drought caused the trees to become charged with sap, and that on the removal of side branches there was an accumulation, in the bark around the cuts, of the sap that would have passed into the branches which had been removed. Under such conditions the cortex contains a surplus of water; the living cells become swollen and bladder-like, and push off the outer corky layers to form the papery bark.

Diseases Caused by Fungi.

Brown Rot Diseases. Brown Rot of fruit was less prevalent during 1938 than usual owing to the scarcity of fruit, but *Sclerotinia fructigena* was responsible for some loss during late summer and autumn particularly on fruit which had been bruised during the severe hailstorm on 12th August. *Sclerotinia fructigena* was found in its conidial (Monilia) stage on a medlar fruit at West Malling. This appears to be the first time it has been noticed on the medlar in this country, although it is so very common on the other core fruits, apple, pear and quince.

Dead shoots from a wall cherry were received from a garden in Sussex. They bore no fungus fructifications but by cultural methods it was found that they were

infected by *Sclerotinia laxa*. Infection of the young shoots, causing Wither Tip, is rather unusual in cherries though instances have previously been seen. This infection of the young shoots is to be distinguished from the Twig Blight which is so common in Morello cherries. The Twig Blight is brought about by infection through the flowers while Wither Tip is a result of infection of the current year's shoots, usually through the leaves.

Apple and Pear Scab. The unusual weather conditions during late winter and early spring affected the incidence of scab and the application of control measures. The mild weather during the early months of the year induced trees to come into flower early and the pink-bud stage in apples followed closely on the green-bud stage. On the other hand the subsequent cold weather, with frosts, killed many blossoms and also caused a long delay between pink-bud stage and petal fall—nearly two weeks between pink-bud and full bloom, and about three weeks between full bloom and petal fall, on Cox's Orange Pippin on this Station. When the first post-blossom spray should have been applied the trees were still in bloom with those flowers which had not been killed by frost. On this Station and in commercial plantations a choice had to be made between spraying the relatively few flowers left and risking damaging them, and delaying spraying at a time critical from the efficient control of scab. The latter was generally adopted with the result that severe infection occurred about that time.

Pears, sent to us in September by a grower near Canterbury, showed Storage Scab, and on the scab spots the Pink Rot fungus, *Trichothecium roseum*, was growing. Storage Scab and Pink Rot are not uncommon on apples that are kept in store for some weeks, but they are unusual on pears, which are usually stored for much shorter periods. The grower wrote that the pears were quite clean when picked on 30th August and stored for a few days to ripen ; the blemishes were observed about a fortnight later.

Angular Leaf Spot. A disease of apple trees, first described as occurring on the Continent in 1935, was observed at Lingfield and at East Grinstead in Surrey in 1937. The disease appeared again in 1938 at Lingfield and specimens were sent to me by Mr. R. G. W. Bush, who had seen the disease in 1937. As the name of the disease implies the spots are distinctly angular ; they are yellowish or greyish brown, and small (mostly about $\frac{1}{25}$ of an inch in diameter), but sometimes they are very numerous so that they coalesce to form larger, irregular blotches. On the spots a fungus, *Phyllosticta angulata* Wenzl, is found, and infection by this fungus is assumed to be the cause of the spotting.

The damage caused by this disease is at present negligible but growers are asked to be on the watch for it to see whether its range is extending. It has been found on the varieties Worcester Pearmain, Bramley's Seedling, Allington Pippin and Newton Wonder.

The first published reference to the occurrence of this disease in Surrey appeared in the Journal of the South-Eastern Agricultural College, Wye, No. 41, January, 1938, page 16, but a more detailed account of it has recently appeared.*

Quince and Medlar Leaf Blight. Quince Leaf Blight, caused by *Fabraea maculata* (*Entomosporium maculatum*) was not so severe in 1938 as in previous years but it was observed again in the stool beds of quinces that are being raised to produce rootstocks for pears, and routine spraying with Bordeaux Mixture appears to be necessary to keep this disease in check.

* Moore, W. C. Trans. Brit. Mycol. Soc. (1939) **22**, 264-6.

The same fungus attacks the medlar and a tree with nearly every leaf infected was found in a garden at West Malling.* As in the quince, severe infection causes the medlar leaves to turn yellow and fall prematurely. There appears to be no consistent difference between the fungus found on medlar and that on quince so the two diseases are assumed to be caused by one and the same fungus.

Medlar Mildew. The medlar is sometimes affected by mildew *Podosphaera leucotricha*, the fungus which attacks also apple, pear, and quince. This mildew was found on a medlar tree on this Station ; it was causing the younger leaves to be somewhat curled and distorted.

Wilting of Shoots in Layer and Stool Beds. This disease was again seen on this Station in layer and stool beds of plum rootstocks. In 1938 it was less noticeable in the main layer rows than in the three or four years previously, a result probably of the dry summer. In some experimental plots, however, it was again serious, and certain seedling plants, that had been stooled, had all their shoots destroyed. The fungus generally associated with this disease proved to be the *Cylindrocladium* isolated previously from infected shoots, but on a few of the shoots killed early in the season the fungus present was *Botrytis cinerea*, and it would seem that this Grey Mould fungus also may at times infect the stool shoots.

Strawberry Fungus Diseases. As a result of the relatively dry summer Grey Mould, *Botrytis cinerea*, was much less severe on strawberries during 1938 than in the previous year, and on this Station the loss caused by this fungus was almost negligible. In the north of England, however, there was more rain as the fruit was ripening and specimens showing the disease were received from Lancashire where again the loss from Botrytis was severe.

On the other hand Mildew, *Sphaerotheca Humuli*, was more prevalent than usual on strawberries ; not only were the leaves infected and curled but the flowers and pedicels also were attacked, the mildew being found on the stamens and pistils ; the infected flowers were deformed, the petals being small and highly coloured.

Black Currant Leaf Diseases. Currant Rust, *Cronartium ribicola*, and the common Currant Leaf Spot, caused by *Pseudopeziza Ribis* (*Gloeosporium Ribis*) were generally not serious in 1938. A little rust was seen on black currants on this Station, and leaf spot was fairly general on some varieties, though even these retained their leaves until well into autumn. During July, however, we received specimens showing severe leaf spot from the Isle of Man where, apparently, the disease was far more severe than in the south of England, for the grower wrote, " The whole row is affected ; the leaves are brown and dropping off, and the fruit is shrivelled and only partially developed." The variety affected was Baldwin's Black.

Another leaf spot of currants is caused by the fungus *Mycosphaerella Ribis* (*Septoria Ribis*). Compared with the Gloeosporium leaf spot this disease is infrequently met with, and I have never seen it in the south of England. During August, 1938, however, I found it in the garden of a farm in North Wales, and it was present also in other gardens in the neighbourhood. This Septoria leaf spot can be distinguished from that caused by Gloeosporium in that the larger spots develop a silvery grey centre, and the fungal fructifications on the affected leaves are different. A more detailed description will be found on page 176.

* This was brought to my notice by Mr. M. H. Moore, who described the disease in *The Gardeners' Chronicle*, 1938, **104**, 440-1.

Raspberry Cane Spot. In December rooted canes of the Norfolk Giant raspberry showing very severe cane spot, caused by *Elsinoë veneta* (*Gloeosporium venetum*), were received from Cambridgeshire. The spots on some canes were almost continuous for several inches, and those canes most severely infected were cankered and distorted. The canes were to be used for planting up and the grower enquired whether it would be advisable to spray them. It was evident that there had been severe infection in the spring, the infection probably coming from the older canes of the stools from which these particular rooted canes had been taken, and spraying should have been carried out then. In such severe infection spraying is very necessary, for, if the succeeding season proves to be one favourable for infection, it is certain that not only will the canes be weakened but the fruit also may become infected and the quality will suffer in consequence.

Verticillium Wilt of Hops. This disease has extended its range and in 1938 was found in 27 hop-gardens in Kent. At the request of hop-growers and with their financial support a special investigation was made of the disease during 1938.* The fungus usually found associated with it is *Verticillium albo-atrum*, but in 1938, in a few instances, the organism isolated proved to conform to *V. Dahliae*. The latter was found associated with an outbreak of the disease in hills of a seedling variety which was under test at this Station. One feature of the disease not previously observed is the development of Verticillium fructifications on petioles and laminae of leaves on withered bines. These fructifications appear to be those of the fungus in the stem, and if this should prove to be so the possibility of the transmission of the disease by means of spores must not be overlooked.

Mangold Violet Root Rot. An outbreak of Violet Root Rot, caused by *Rhizoctonia Crocorum*, occurred on Bradbourne Farm in a four-acre field of Yellow Globe mangolds. In nearly half the field 50 to 70 per cent. of the roots were affected and a few isolated plants showing the disease were found in other parts of the field. The fungus was also found on a number of weeds growing in the same field, i.e. Knotgrass (*Polygonum aviculare*), Persicaria (*P. Persicaria*), Corn Mint (*Mentha arvensis*) and Goosefoot (*Chenopodium album*). That portion of an affected mangold below ground level was covered with the violet coloured felt bearing the minute sclerotia typical of this disease, while just above ground level the fungus grew out as a weft of mycelium, forming a white zone round the root. On pulling up badly affected plants the lower portion of the roots remained behind in the ground and probably in this way the soil has become heavily charged with the parasite.

The chief interest in the outbreak as affecting this Station is that the field is part of the estate recently acquired by the Station and it has been proposed shortly to plant strawberries in the same field ; there now seems to be a risk that, if this proposal is carried out, the strawberry plants may become infected for (as mentioned in the Report of this Station for 1931, page 50) strawberry plants have been seen bearing the same fungus. An experiment, to ascertain whether strawberries planted in this soil are likely to become infected, is under way.

Grey Mould on Dandelion. The Grey Mould, *Botrytis cinera*, is frequently mentioned in these notes as causing damage to various crops and references to its occurrence on strawberries and on plum shoots appear in this article. The possibility that weeds may at times be a source of infection for crop plants was suggested by

* Mr. W. G. Keyworth was appointed in July, 1938, to undertake this research. His report for 1938 will be found on pages 244-9.

finding the Grey Mould on dandelion heads in one of the plantations on this Station.* The flower heads were killed and almost covered with the fructifications of the fungus, which had extended for about half an inch down the flower-stalks. To ascertain whether the fungus was able to attack fruit it was isolated from the dandelion, grown in pure culture, and then inoculated into apples. All the apples became infected and a brown rot developed which eventually affected the whole fruit, while numerous Botrytis fructifications appeared on the rotting apples. Control apples kept under similar conditions, but not inoculated, remained sound throughout the experiment.

Bacterial Diseases of Fruit Trees.

Bacterial Canker of plum and cherry trees continues to be one of the most troublesome diseases of the stone fruit trees, as shown by the many enquiries we receive regarding it. On this Station it was not serious in 1938 except on certain trees on the "stem-builder" trial plot where the Victoria plum trees on certain varieties used as stems suffered much more than on others. Up to the present the trees on Purple Egg and Myrobolan B have not developed cankers, while those on Pershore (Yellow Egg) stems suffered as severely as the trees with Victoria stems.

Bacterial infection of the fruit is rare. One cherry was found on one of our plots, associated with leaf spot. Cherry fruit spot has been found occasionally previously, but only once has it proved to be at all serious. The possibility of the fruit becoming infected on trees with severe leaf spot must not be overlooked however.†

On Morellos on this Station a bacterial leaf spot was observed on trees of two plots. The organism isolated from such spots appears in preliminary tests to be identical with *Pseudomonas mors-prunorum* which causes Bacterial Canker of other stone fruit trees, and inoculation experiments have been carried out to ascertain whether this organism from Morello leaves is able to infect the sweet cherry and plum. The organism found in previous years associated with leaf spotting in Morello cherry is one which produces colonies quite different from those of either of the two organisms causing bacteriosis in plums and sweet cherries, but it has not yet been identified; this organism was not met with in isolation tests from Morello leaves in 1938.

Bacterial Blight of pear blossoms has again occurred on this Station but not causing any serious damage. Specimens were received also from North Kent and from Jersey. The organism usually found associated with this disease shows affinities with *Pseudomonas prunicola* and may be identical with it. The specimens from Jersey however yielded a bacterium which in culture resembled the organism, not yet identified, sometimes found associated with leaf spot and bacterial blossom blight of acid cherries.

Bacterial fruit spot of pears (mentioned in the Annual Report for 1936, page 192) has not been observed again since 1936, but in 1938 a spotting of pear leaves was seen and the tissues of the spots were found to contain numerous bacteria; the organism isolated appears to be identical with that found in the wilted tissues of blossom and that of pear fruit spot, and it seems likely that the same organism is able to infect the leaves, flowers, and fruit.

Virus Diseases.

The virus diseases of raspberry (Mosaic) and strawberry (Yellow-edge and Crinkle) continue to be the most serious diseases of these two crops. Strawberry Yellow-edge appears to be the most important factor in reducing the cropping, particularly in the

* The specimens were brought to me by Dr. W. S. Rogers.

† See p. 173.

very susceptible varieties Royal Sovereign and Sir Joseph Paxton. Severe Crinkle however is also serious in some plantations. It must be emphasized that these two diseases should be kept in check by rigorously removing all infected plants as soon as the particular symptoms are noticed, and by keeping the Yellow-edge vector (the strawberry aphis *Capitophorus fragariae*, under control.* There are certain " carrier " varieties, such as Tardive de Leopold and Huxley's Giant, which are less susceptible in that the disease does not reduce their vigour so rapidly, and they may have the virus within their tissues for some time without showing any obvious signs of deterioration. Such carrier varieties should not be grown in the vicinity of the more susceptible varieties.

When starting new plantations of strawberries it is advised that the runners should be obtained from special runner beds, raised from healthy plants and kept as free from virus as possible by careful attention to control measures.

The Nettlehead Disease of hops has been very serious on some farms and very many affected plants have had to be grubbed during 1938 not only in Kent but also in the West Midlands. From preliminary experiments carried out by Professor Salmon and Dr. Ware of the South-Eastern Agricultural College, Wye, the Nettlehead condition would appear to be a virus disease. Further investigation on this disease seems to be imperative ; meanwhile growers are advised to remove and burn promptly any plants showing the symptoms of Nettlehead, i.e. numerous small spindly bines bearing rather pale foliage, the leaves having their margins curled *upwards*, not downwards as in the Hop Mosaic disease.

Summary.

Certain non-parasitic, fungal, bacterial, and virus diseases of fruits and hops, observed during 1938, are noted. These include (1) severe Scab infection on apples due to unfavourable weather conditions in March and April, (2) Angular Leaf Spot of apples (*Phyllosticta angulata*), (3) Medlar Leaf Blight (*Fabraea maculata*), (4) unusually severe attacks of Strawberry mildew (*Sphaerotheca Humuli*), (5) Septoria Leaf Spot of black currants (*Septoria Ribis*), and (6) severe outbreaks of Verticillium Wilt and Nettlehead Disease in hops.

* See the article by R. M. Greenslade and A. M. Massee on page 250.

BACTERIAL ROT OF CHERRY FRUITS

By H. WORMALD

In former papers (1, 2) it was shown that serious damage to cherry trees in Britain is caused by bacterial infection of the stems, branches and leaves, and a passing reference was made to infection of the fruit. From time to time cherry fruits showing blemishes, with bacteria in the discoloured tissues, have come to my notice and although up to the present the damage from such infection has been negligible, except perhaps on one occasion, it seems desirable to point out that bacterial infection of the fruit does sometimes occur.

This disease was first observed in 1929. During the first week of July that year cherries showing dark blotches were sent to East Malling from an orchard at Newington in North Kent, with an enquiry from the grower as to the cause of the blemishes. When the tissues of the blotches were teased out in water and examined under a microscope numerous rod-shaped bacteria were seen to ooze out. This suggested that the discoloration was caused by bacteria, so a visit was paid to the orchard and the affected trees were examined. There was a marked fruit-fall of the green cherries, but this appeared to be due partly to imperfect pollination, for the fallen fruit did not all show the spotting, and the stones of fallen fruits which were not spotted had poor kernels.

The variety affected was Napoleon. The lesions on the fruit were of various sizes, the largest occupying about three-quarters of the surface. Such blotches were found not only on the fallen fruit but on cherries still on the trees.

Numerous bacteria were found in the tissues of all the lesions examined microscopically. The enormous number of bacteria present in a diseased cherry was seen when some of the specimens showing the rot were placed in 1 per cent. formaldehyde solution for preservation as museum specimens. Three days afterwards it was noticed that from one of these preserved cherries a whitish worm-like gelatinous mass had been extruded ; it was curved and rather flat, 1.5 cm. long, 0.6 cm. in width, and 0.2 cm. thick. A small portion was cut off, smeared on a slide and stained ; it was then seen to be a dense mass of bacterial rods embedded in a matrix, which was probably of a gelatinous nature since it had swelled up and exuded when the fruit was placed in the fluid.

Culture plates were prepared from the infected tissues of a number of the cherries, using nutrient agar containing 5 per cent. cane sugar, a medium that had been found useful for isolating the organisms associated with bacterial cankers and leaf spots of stone fruit trees. The colonies which appeared on the plates resembled, in their structure, those yielded by the bacteria causing cankers and leaf spots of cherries.

Isolations from four different cherries were used in experiments on young green growing cherries, which were inoculated through needle punctures ; two of the strains yielded positive results, in that most of the inoculated cherries showed blackened areas round the punctures within four days, and six days later the lesions were sunken and from 1 to 4 mm. in diameter. The lesions were found to contain numerous bacteria, and from one cherry in each set the organism was re-isolated and grown in pure culture.

Certain cultural tests were applied to the two strains which yielded these positive results ; one of them gave the reactions of *Pseudomonas prunicola*, the other strain

those of *P. mors-prunorum*, the two organisms which have been found to infect leaves, branches and stems of cherry trees (3). Each of the two strains re-isolated from the inoculated cherries behaved in culture like the particular strain used in the inoculation.

It is concluded from these experiments that, given conditions suitable for their development, these two organisms are able to produce a spotting or rotting of the fruit. Whether a wound is always necessary for the organism to gain an entrance has not been determined. In the experiment described infection arose only at the punctures, but on naturally infected cherries no wounds have been seen. As shown in Fig. 1 the natural lesions are mostly at the lower end of the fruit, where drops of moisture would accumulate and remain for some time in wet weather ; such conditions would favour infection, which probably occurs during rainy periods.

In 1931 a single fruit showing a similar lesion was brought to me by Mr. N. H. Grubb from a cherry tree on this Station. The tree had bacterial cankers on its branches, and it is probable that infection of the fruit arose by the splashing of bacteria by rain from the branch cankers or leaf spots on to the fruit. As before, it was found that the tissues of the fruit spot contained numerous bacteria and these when isolated on culture plates yielded colonies resembling those obtained from similar spots in 1929. In culture tests the organism gave the reactions of *Pseudomonas mors-prunorum*. Inoculations on cherry fruits using this strain resulted in lesions up to 3 mm. in diameter within three days, and the organism was re-isolated from one of the lesions.

In 1933 a fruitgrower at Brenchley, Kent, brought to the Station a cherry (variety Early Rivers) with a black blotch 1·5 cm. long which again contained numerous bacteria. Bacterial cankers and leaf spotting were present on the same farm and the tree on which the diseased fruit was found showed leaf spots. Isolations were obtained from the fruit spot and from a leaf spot of the same tree, and the two organisms were found to conform to *P. mors-prunorum*. Both strains were inoculated into cherry fruits and both produced lesions.

During the first week of November the fruit spot strain was inoculated into cherry branches, and by the following summer all the inoculations had resulted in cankers from 4 to 8 cm. long half girdling the branches and exuding copious gum.

The disease was not seen again on cherry fruits until 1938 when it was found on one of the plots of cherries on this Station :* only a single cherry, however, was seen with the spotting but possibly a search would have revealed others similarly infected. The organism isolated conformed to *Pseudomonas mors-prunorum* in the tests applied to it.

Bacterial spotting of cherries has therefore been seen in this country on four occasions. On three of these it was found on single fruits only, but on the first occasion the disease was sufficiently serious for the grower to enquire as to the cause and remedy. The disease on the fruit is usually accompanied by bacterial leaf spots or cankers and this suggests that the fruit may become infected by bacteria splashed by rain from lesions on the leaves and branches and it is unlikely to occur on trees free from such lesions.

Infection of plum fruits by *Pseudomonas mors-prunorum* has been seen on two occasions. On plums however the spots hitherto observed have been smaller than those on cherries, more circular, and rather like small scabs about $\frac{1}{10}$ inch in diameter. On cherries the lesions are usually larger, more irregular, and somewhat sunken.

In America bacterial spotting of the fruit of plum and peach is caused by another organism, *Bacterium Pruni*, which attacks also the foliage and twigs. This bacterial

* By Dr. H. B. S. Montgomery.

FIG. 1.
Naturally infected cherries showing blemishes due to infection by bacteria.

a *c* *b*

FIG. 2.

a. Cherries inoculated with a strain of *Pseudomonas prunicola* isolated from a diseased cherry.
b. Cherries inoculated with a strain of *Pseudomonas mors-prunorum* isolated from a diseased cherry.
c. Control cherries, punctured but not inoculated.

Black Spot of stone fruits may be very severe and sometimes at least half the fruit in peach orchards is infected. It is not known to occur in Europe.

Since bacterial fruit spot in cherries and plums has not yet proved to be serious in this country, no control measures against this disease only can be advised, but, as it usually accompanies bacterial canker and leaf spotting, steps taken against these diseases should prevent fruit infection also. The treatment recommended is spraying with Bordeaux mixture, which is prepared according to the formula* 10 : 10 : 100 for use on the stems and branches in autumn, and at 3 : 3 : 100 for application to the foliage in spring.

Summary.

A bacterial spotting of cherry fruits has been seen in this country on four occasions. *Pseudomona prunicola* and *P. mors-prunorum*, generally the latter, have been isolated from such fruit lesions.

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* These formulae are for Bordeaux mixture prepared with quicklime; when hydrated lime is used they become 10 : 15 : 100 and 3 : 4½ : 100 respectively.

THE SEPTORIA LEAF SPOT DISEASE OF BLACK CURRANTS*

By H. WORMALD

THE foliage of currants is often conspicuously spotted or blotched as a result of fungus infection, which, when severe, not only reduces the assimilating leaf surface of the individual leaves, but, in addition, induces premature defoliation, so that the effective leaf area is still further diminished and the bushes tend to become weakened in consequence. Three diseases which produce leaf spots or blotches on currant leaves in Britain are the Currant Rust, the Gloeosporium Leaf Spot, and the Septoria Leaf Spot.

The Currant Rust, *Cronartium ribicola* J. C. Fischer, is widespread; it is very common in this country, but, as it usually appears rather late in the season, it is not so destructive in general as the Gloeosporium leaf spot. During the summer small yellowish wart-like pustules, that produce the uredospores, appear on the under side of the spots. In the later stages of its development the fungus is readily recognized by the numerous hair-like outgrowths on the lower side of the affected leaves. These hairs consist of the teleutospores, and sometimes they are so numerous as almost to cover the entire lower surface of some leaves.

The common leaf spot of currants is caused by *Pseudopeziza Ribis* Kleb.; it is one of the most troublesome diseases of Black Currants, and the spotted foliage bearing the blister-like fructifications of the imperfect stage of the fungus, *Gloeosporium Ribis* (Lib.) Mont. and Desm., has been of common occurrence in recent years, especially in seasons when the rainfall has been above the average (Figs. 1a and 1b). It sometimes appears so early in the season that bushes are partially defoliated before the crop is picked, and, as a result of this, the fruit tends to shrivel on the bushes.

Less frequently observed is another currant leaf disease which, on a casual examination, may be confused with the Gloeosporium spot. The fungus associated with this disease is *Mycosphaerella Ribis* (Fuckel) Kleb., and its imperfect stage on the living currant leaves is known as *Septoria Ribis* Desm. Thus, although the spots produced by this fungus and by the Gloeosporium have some superficial resemblance, particularly in the early stages of their development, the conidial fructifications form a ready means of distinguishing the two, and the pale centre of the larger Septoria spots is also a characteristic feature.

It would seem that the Septoria Leaf Spot is rather uncommon, but, since it may be mistaken for the Gloeosporium spot, there is the possibility that spotting caused by *Septoria Ribis* has at times been attributed to *Gloeosporium Ribis* and that the Septoria is more widely distributed than is generally assumed.

M. C. Cooke in his "Fungoid Pests of Cultivated Plants" (1906) says (page 143), "This spot appears to be confined to the living leaves of the Black Currant, and is certainly common enough", and W. B. Grove in "British Stem- and Leaf-Fungi, I",

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(1935) writes (page 493), "On fading leaves of *Ribes nigrum, R. rubrum,* and other species of Ribes. Rather common, but not doing much injury. England, Scotland." Since these authors describe the disease as " common " and " rather common " it is somewhat surprising that it has not been more frequently reported in recent years. Thus in the published reports of the Ministry of Agriculture on the fungus diseases of crops, covering the years 1917 to 1932 there is only one mention of this disease—in Bulletin No. 79 (1934) page 81, where it is reported that " *Septoria Ribis* Desm. was noted in Somerset in 1930 and 1931, but was of minor importance ". It was found on the Spring Foray of the British Mycological Society at Hazlemere, Surrey, in May, 1921 (Trans. Brit.

Conidia of *Gloeosporium Ribis.*

Conidia of *Septoria Ribis.*

Mycol. Soc., VII, 1922, page 224), and again by Dr. Alex. Smith during the Autumn Foray of the Society at Aviemore in Inverness-shire in September, 1938. Dr. Smith informs me that he has seen this disease in Aberdeenshire, also.

During August, 1938, I found this Septoria disease on black currant bushes in the kitchen garden of a farm near Abersoch in North Wales. It was evidently a severe infection for all the currant bushes in the garden were attacked and on some of them nearly every leaf was very badly spotted. Only a few leaves had fallen, so there was no serious defoliation at that time, and the chief result of the infection was the large area of leaf surface destroyed ; this, however, must have had an adverse effect on the growth of the bushes, since some of the leaves had more than half their area killed by the fungus. Fig. 2a shows the type of injury, but on many leaves the spots were far more numerous. Similar symptoms were seen on bushes in other gardens in the same neighbourhood.

It would seem that when the conditions are favourable for the fungus this disease may become severe, especially in neglected gardens, and the possibility of its extending its range, as serious infections, to commercial plantations must not be overlooked. As it may so easily be confused with the Gloeosporium leaf spot a more detailed account of it may be of some interest, so that growers and others may be able to recognize it.

The spots, in the early stages of their development, are very small, dark, angular and sharply defined, but as they increase in size their angular outline becomes less pronounced and some spots are then almost circular. These larger spots, which may reach a diameter of about one-tenth of an inch, become grey (almost white) centrally, leaving a narrow, dark brown border. Usually a seriously infected leaf shows both small angular spots and the larger pale spots (Fig. 2a). The spots are sometimes very numerous and then become coalescent, particularly round the edges of the leaves and towards the tips of the lobes, so that comparatively large portions of such leaves are affected.

The rather large, roughly circular, pale spots with dark borders, serve, in the open, to distinguish this Septoria leaf spot from that caused by Gloeosporium. For confirmation of the diagnosis the spots should be examined next with a hand-lens. Instead of the blister-like pustules (acervuli) of Gloeosporium the Septoria produces smaller, spherical, dot-like black pycnidia, hardly visible to the naked eye but easily seen with a lens ; they are mostly on the under side of the spots, and particularly on the lower sides of dead terminal teeth of the lobes of the leaves (Fig. 2b).

Under moist conditions the pycnidia emit pinkish " tendrils " consisting of numerous long, narrow, threadlike conidia, very unlike the shorter crescent-shaped conidia of the Gloeosporium.

The Septoria conidia mostly measure 45 to 55μ by about 2μ. M. C. Cooke says the length is 50μ, and W. G. Grove gives the dimensions as 40-50 $\times$ 1.5-2μ. I found the conidia, in the specimens collected in Wales, to be from 36 to 72μ long by 1.5 to 3μ, conidia over 60μ in length being not uncommon. They were mostly distinctly curved but some were nearly straight. Each conidium had a row of guttules and, when fully mature, 4 or 5 septa.

In America and on the Continent an ascigerous fungus, a species of Mycosphaerella, is known to occur on over-wintered currant and gooseberry leaves that in summer had borne the Septoria. R. E. Stone, an American worker, showed by inoculation experiments that these two stages belonged to the same fungus, which he referred to as *Mycosphaerella Grossulariae* (Fr.) Lindau. In 1918 these results were confirmed by Klebahn but he gave the Mycosphaerella the specific epithet *Ribis* used by Fuckel, who had named the fungus *Sphaeria Ribis*. The Septoria stage is found on the spots of living leaves, while the Mycosphaerella stage develops on the fallen leaves, and in spring liberates ascospores to infect the young foliage, resulting in leaf spots that bear the Septoria fructifications.

In America the Septoria leaf spot appears to be rather common and sometimes severe. Hesler and Whetzel, describing this disease in their Manual of Fruit Diseases (1922) page 203, write, " In some seasons nearly complete defoliation occurs. This loss of foliage interferes with the maturing of both the wood and buds, and as a result the succeeding crop is injured." It may be noted in passing that in this book the illustrations of the Septoria and the Gloeosporium leaf spots are transposed.

For the control of this disease the same measures may be adopted as those advised for the Gloeosporium leaf spot. For the latter Marsh and Maynard (Jour. Min. Agric. XXXVII, 1938, 255-259) recommend spraying with Bordeaux mixture immediately

Fig. 1a
Black Currant Leaf with Gloeosporium Leaf Spot.

Fig 2a
Black Currant Leaf with Septoria Leaf Spot.

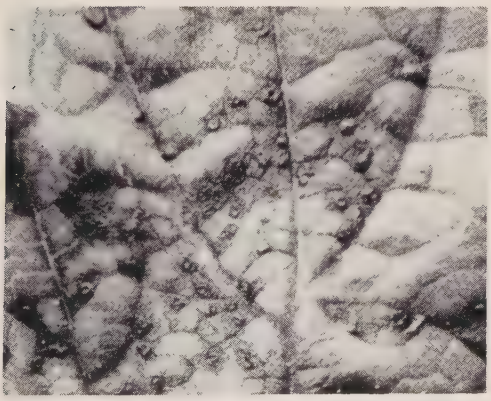

Fig. 1b
The Gloeosporium fructifications as seen with a lens.

Fig. 2b
The Septoria fructifications as seen with a lens.

the fruit is picked. This will check infection of the younger leaves and arrest defoliation. When it is practicable, as in gardens and small plantations, the further precaution should be taken of raking up the fallen leaves and burning them.

Summary.

Mention is made of a severe outbreak of the Black Currant Leaf Spot caused by *Mycosphaeralla Ribis* (*Septoria Ribis*), near Abersoch, North Wales, in August, 1938. A description of *Septoria Ribis* is given, and the Septoria Leaf Spot is compared with that caused by *Pseudopeziza Ribis* (*Gloeosporium Ribis*). The control measures suggested are those which have been recommended for the Gloeosporium Leaf Spot.

ENTOMOLOGY

NOTES ON SOME INTERESTING INSECTS OBSERVED IN 1938

By A. M. MASSEE

1. *Batophila aerata* Mm.

This small Chrysomelid beetle, which is closely allied to the flea beetles, was found freely on the leaves of Himalaya Blackberry at East Malling during the months of April and May. It feeds on the foliage, and becomes very active when disturbed. Its normal host plant is the wild blackberry, but it frequently feeds on the raspberry as well.

A closely related species, *Batophila rubi* Pk., which is the more common of the two, also feeds upon cultivated Rubi— in addition to the wild blackberry—but it has not been noticed in the Maidstone district for several years.

B. aerata Mm. was found in profusion on the leaves of raspberry, growing in a garden at East Malling, during October. Although the movements of the beetles could be heard several feet away, they did not appear to be causing any damage to the canes of the plants.

2. Apple Bud Weevil (*Anthonomus cinctus* Redt.).

The Apple Bud Weevil was first recorded in this country in 1921, from Darenth Wood, Kent, where a single specimen was found on crab apple. Since that time it has been recorded from many parts of the county, and it has occurred also in Cambridgeshire.

It still occurs sparingly in apple orchards in various parts of Kent, and specimens have been received from East Malling, East Farleigh, Maidstone and Swanley, during 1938.

The larva of this weevil feeds within the fruiting buds, and is partial to certain varieties, among which may be mentioned Newton Wonder, Bismarck, Allington Pippin, and Type XI rootstock. It is curious how this insect just manages to survive year by year, without ever becoming very abundant, not even in badly neglected orchards, or in those which are never sprayed.

3. *Otiorhynchus ovatus* L.

This small, pitchy-black, wingless weevil is included in the same group as the Clay Coloured Weevil, but it is much less common in many parts of Kent. Its normal habitat is low growing vegetation, but it may be sought for also at the roots of plants, in moss, under stones and in dead leaves.

In the summer of 1936 and in July, 1938, the adult was found damaging the buds of apple and plum stocks in the propagation beds at the Research Station. The damage it causes is similar to that made by the Clay Coloured Weevil, for it nibbles at the bark of the stems, which are frequently girdled. It also feeds on the petioles, often severing the leaves, thus causing partial defoliation. So far the attack has been very localized, and there is no reason to assume it will increase unduly.

The weevil feeds mainly at night, the day being spent in hiding under stones, clods of earth, etc. It is thus very difficult to find unless a careful search is made. Its larva attacks the roots of strawberry, often causing severe injury.

4. *Aphodius fimetarius* L.

A number of grubs of a species of dung beetle were sent to East Malling from a private garden at Knockholt, Kent. The owner of the garden reported that the grubs were causing very serious damage to cabbage plants by feeding on the fibrous roots, and destroying most of them. In many instances the whole root system was destroyed, and the plants died off within a few days. The owner of the garden was convinced that the dung beetle grubs were the cause of the trouble, and said that they had been imported with some manure he had recently purchased. Larvae similar to those found on the cabbage patch were found in numbers in the manure heap.

In order to verify the view that the dung beetle larvae were actually causing the damage attributed to them, it was decided to breed a number of the larvae in pots at East Malling. For this purpose a number of small cabbage plants were potted up, and several larvae were placed on the top of the soil in the pots. Control plants were potted up also. The larvae burrowed into the soil within a few minutes, and were not seen on the surface again. After a period of three weeks the plants began to turn yellow; the lower leaves dropped off, and finally all the plants began to wilt. An examination of the roots showed that most of the fibrous rootlets and part of the main roots had been eaten away. All the larvae were still living, and on being transferred to fresh potted plants, soon began to bury themselves. Adult beetles emerged on 8th August, about five weeks after they were first placed on the soil in the pots. The species proved to be *Aphodius fimetarius* L. in each case.

The above observations are of more than passing interest, since dung beetle larvae do not normally attack the roots of cultivated species of Brassica or other root crops. It is clear, however, that they will feed readily on the roots of cabbages in the absence of other food. Dung beetle larvae have been reported as pests from time to time, but this would appear to be the first authentic record in this country.

It is of interest to note that the same species of dung beetle has been reported as injurious in Germany on two occasions. In one instance the larvae were found causing damage to mushroom beds, by their tunnelling about in the soil, and checking the growth of the mushroom spawn. The larvae have been suspected also of damaging the rootlets of newly planted strawberries.

5. Apple Leaf Miner (*Lyonetia clerkella* L.).

This insect proved to be unusually common in the Maidstone district in 1922 and 1923, but since that period it was not often seen until the autumn of 1938.

Caterpillars of the second generation were frequently noted at East Malling in October feeding on the foliage of apple rootstocks. Moths were reared successfully in November.

The caterpillar of the Apple Leaf Miner burrows in the leaf tissues of apple and hawthorn, and the irregular galleries made by it are very characteristic. As a general rule the caterpillar leads a solitary life, only one inhabiting a single leaf. When fully fed, it leaves the mine and proceeds to spin a hammock-like cocoon (see Fig. 1), usually on the under surface of the leaf in which it has been feeding, but it may move off to pupate elsewhere. The pupal stage lasts from ten days to three weeks.

There are two broods in a season, the second brood hibernating in the adult stage, in old rubbish, dry leaves, and other sheltered places.

The Apple Leaf Miner occurs also on strawberry, but it has not been observed to cause any harm to the plant.

6. Common Marbled Carpet Moth (*Hydriomena truncata* Hufn.).

The " looper " caterpillar of the Common Marbled Carpet Moth occurs commonly on strawberry in the Maidstone district ; it seems to be more plentiful now than formerly, but must not be regarded as a pest.

The fragile caterpillar is green, inclining to yellowish in many specimens. There are three lines along its back, the centre one being greenish and the others yellowish ; sometimes there is a purple-rosy stripe along the sides. Two reddish pointed processes are present on the anal segment.

There are two generations in a season. The first brood appears in May and June, and the second in August and September. The caterpillars may be found feeding on the foliage in July and August, and again from September until April. Thus the winter is spent in the caterpillar state.

7. Cherry Fruit Moth (*Argyresthia nitidella* Fabr.).

Although the Cherry Fruit Moth has been present in the cherry growing districts of Kent for many years past, it has not been very common, and in consequence growers, with a few exceptions, have not worried about this important insect pest. It should be noted, however, that this cherry pest is more prevalent now than formerly.

As might be expected the headquarters of this insect are in the Faversham and Sittingbourne districts, where it was reported by several growers in 1938.

The minute caterpillars of this moth infest the fruitlets and feed on the flesh. A number of infested fruits were sent to East Malling from Faversham at the end of April, and the grower reported that the damage was becoming more serious each year.

In a season such as that experienced in 1938, when the crops were very slight, it might well be that the infestation was concentrated on the few fruits which escaped the frosts, but even so, a pest of this nature must not be allowed to increase unduly without some measure of control being directed against it.

8. Apple Clearwing (*Conopia myopiformis* Borkh.).

An interesting example of Apple Clearwing damage was received from Swanley in October, 1938.

Some peach trees growing on a wall were dying back, and the main stems were seen to be exuding an unusual amount of gum. Further observations showed that the stems were being attacked by the larvae of some insect, which at the time was considered to be a species of wood-boring beetle.

A detailed examination of some of the shoots and stems sent to East Malling, proved that the larva of the Apple Clearwing Moth was responsible for the damage, and that the gumming of the stems was the direct result of larvae boring in them. It is well known that the larva of this moth makes its galleries just beneath the bark, and that the larva lives and feeds until mature in such situations. When ready to pupate it works its way to the surface before turning into the chrysalis state. Thus the moth can emerge with ease when the time comes.

As its name indicates, the Apple Clearwing is more normally associated with apple, hence it is of interest to find it causing so much harm to old and young peach trees.

It has been found that thoroughly scraping the bark to remove the gummy excretions, and painting the stems with ten per cent. tar distillate wash has killed a large

number of the caterpillars, but it is proposed to treat the stems again next spring just before the caterpillars are due to pupate as a further precaution.

9. Leaf Curling Black Currant Midge (*Dasyneura tetensi* Rüb.).

The Leaf Curling Black Currant Midge has spread over a wide area of Kent in the last few seasons, since it was first recorded on a field scale at Matfield some eight years ago. It is now very common in the Maidstone district, and it is also very troublesome in certain parts of Hampshire.

In 1938 a very severe infestation was reported from Alton, Hampshire, on 10th May, which is very much earlier than it has been recorded hitherto.

As already stated the midge is increasing year by year, and there is little doubt that if it continues to do so at the present rate, it may become a serious pest of Black Currant. Already it is causing the nurseryman considerable annoyance because of the injury it causes to the shoots. It curls most of the leaves at and near the tips of the new shoots, frequently causing the apical buds to die, thus stopping the growth and producing forked growths below it.

Several growers report that nicotine is of little or no use, and that dipping the affected growths in a nicotine wash has not proved worth while.

Commercial naphthalene broadcast under the bushes, at the rate of 4 cwt. per acre, has proved equally ineffective.

In common with so many other pests, it is doubtful whether adequate control measures will be found until the habits and life-cycle of the insect are understood more completely.

10. Hop Strig Maggot (*Contarinia humuli* Tolg.).

The Hop Strig Maggot seems to have very variable habits, since some years it is very plentiful, and it is reported by growers from various parts of Kent, giving one the impression that it may become a serious pest. Instead of increasing still more the following year, however, it seems to disappear and it is not noted again for two or three seasons.

In 1938 it was reported by hop growers on several occasions. Bad outbreaks were noted at Penshurst, Tenterden and Paddock Wood. Smaller infestations were reported from the Marden and Maidstone districts.

Little is known regarding the life history of the midge, but observations show that the adult midges fly about in the hop gardens at the period when the hop cones are just forming. It is possible that a derris dust applied at this season may check the infestation to some extent, but experimental work will have to be carried out before this measure can be recommended with confidence.

A well-known hop grower states that he has used naphthalene on several occasions without any obvious success.

11. Aphides on Apple and Pear.

Some confusion exists regarding the species of aphides which feed on apple and pear, since many of them cannot be recognized at a glance in the field. For example, there is some doubt whether the common leaf curling species on pear is the Rosy Apple Aphis, *Anuraphis roseus* Baker, or whether the pear supports a closely related species of its own.

In any case the fact remains that the leaf curling aphides of apple and pear have been much more prevalent in 1937 and 1938 than for several seasons past. The leaf

curling species may be found commonly in apple and pear orchards which have received their routine application of tar distillate wash, and there seems to be no reasonable explanation for this phenomenon.

The Rosy Apple Aphis has been reported from many parts of Kent as occurring on both apple and pear, but the enquiries have mainly concerned its attack on the pear. A very severe infestation occurred at Gillingham on some Conference pears, which incidentally had not been sprayed with a tar distillate wash the winter previously. Most of the aphides had migrated by 28th June, and the few which remained were mostly winged forms ready for departure. Since the Greater Plantain is an alternative host of this aphis, a search was made for it in the orchard. A few plants were found growing under the trees in the orchard, and colonies of aphides were established on each. Winged forms were present, and many apterous forms were found on the stems just above the ground level. The species is considered to be identical with that noted on the pears in the same orchard.

A search was made for the same species on apple in an orchard near at hand, but none was found, although it was evident by the leaf curl that it had been present a week or so previously. Curiously enough aphides were not found on the plantains growing in the apple orchard, although they were quite plentiful.

A small black aphis has been causing severe leaf curl on some cordon pears growing on a wall at the Research Station. The damage is very conspicuous, and the aphid appears to be partial to certain varieties.

It has been breeding there sparingly on the same trees for several years, but it became far more numerous in 1938.

12. Blackberry Leaf Miner Sawfly (*Entodecta pumila* Klug.).

At least six species of sawfly are associated with wild blackberry and cultivated species of Rubus, and the larvae of most of these feed on the foliage during the summer months.

It is of interest to record, therefore, a species which may be described as a true leaf miner. The caterpillar is very peculiar in appearance owing to its flattened body, otherwise it is typical of the group. It mines within the tissues of the leaves, making large irregular galleries (see Fig. 2).

This insect was found in small numbers at East Malling on blackberry and raspberry. The species was noted in the same locality some years ago.

This interesting insect must not be regarded as a pest of species of Rubus, but its presence seems worth while recording in these notes.

13. Hop Red Spider (*Tetranychus telarius* L.).

The Hop Red Spider has been referred to several times in these notes during the past ten years, and from the numerous enquiries received concerning it in 1938, it would appear that it is still a considerable source of worry to the hop grower. It may well be that growers recognize this pest in the field more readily now than in the past.

Complaints have been received from the Maidstone district, Paddock Wood, Farleigh, Cuxton, Tenterden, Tonbridge, Marden and other parts of Kent.

A point of interest regarding the enquiries in 1938 is that they have been received much earlier than usual, namely in June and July, whereas in other seasons information concerning this pest is sought in August, just before the picking is due to begin.

The practice of controlling the mite by the lime-sulphur treatment is being used commercially more extensively every year, and it has displaced the use of liver of sulphur almost entirely.

FIG. 1.
Cocoon of the Apple Leaf Miner (*Lyonetia clerkella* L.) on a strawberry leaf.

FIG. 2.
Larva of Blackberry Leaf Miner Sawfly (*Entodecta pumila* Klug.) within leaf tissues.

14. The Fig Mite (*Eriophyes ficus* Cotte).

A number of fig leaves exhibiting characteristic mottlings and blisters on their upper surface were sent to East Malling in July, 1938. Further material was received a month later and a species of Eriophyid mite was found to be the cause of the trouble.

This is the first time the mite has been recorded in Great Britain, although it is well known on the Continent. It was first described by Cotte in 1920 under the name of *Eriophyes ficus*.*

Another species of fig mite has recently been received from Turkey, but it is not the same species as that referred to above. The Turkish species produces blisters on the maturing fruits.

Summary.

Brief notes are given on some unusual insects found on fruits and vegetables in 1938.

Aphodius fimetarius L. was found damaging the roots of cabbages at Knockholt, Kent. The Cherry Fruit Moth (*Argyresthia nitidella* Fabr.), and the Apple Leaf Miner (*Lyonetia clerkella* L.), proved more common than usual. The Apple Clearwing (*Conopia myopiformis* Borkh.), was found infesting the stems of peach in an unusual manner. Reference is also made to certain aphides which infest apple and pear.

* Cotte, T. H., *Bull. Soc. Pathol. veget.*, 1920, **7**, p. 26.

THE CONTROL OF STRAWBERRY APHIS AND TARSONEMID MITE

By R. M. GREENSLADE and A. M. MASSEE

The Strawberry Aphis (*Capitophorus fragariae* Theo.) and Strawberry Tarsonemid Mite (*Tarsonemus pallidus* Banks) are the two most important pests of cultivated strawberries in England and are particularly difficult to control in the field. The aphis transmits virus diseases of the strawberry plant and as very few or possibly only one infected aphis will cause a plant to become diseased it is obvious that complete control is necessary. The aim of the strawberry grower, particularly the grower who raises runners, must be the complete extermination of the aphis. This is not yet economically possible but the progress made toward that end is published in order to demonstrate the difficulties and the limitations of present methods. Exact figures for the results described are not given as suitable sampling methods had not been worked out when the earlier work was done. Where one treatment is stated to be better than another it may be understood that the difference in result was such as to be obvious without the necessity of sampling methods. A method of sampling aphis population has now been worked and will be used in future work.

It may also be of interest to give an outline of the many methods used in attempting to control the Tarsonemid Mite in the field before that idea was given up in favour of the treatment of runners before planting.

Strawberry Aphis.

When the transmission of virus diseases by *Capitophorus fragariae* was discovered attempts were made to control the aphis in the field and slight success was obtained by spraying with nicotine and soft soap. Nicotine dusts and derris were practically useless. The lack of complete control appeared to be due to inefficient wetting as all aphids which were touched by the spray were killed. The low growing habit of the strawberry plant makes it difficult to spray. The older leaves especially lie close to the ground and spraying drives them down so that aphides on the under side are not reached by the spray. Also the under side of the leaf tends to repel the spray so that good wetting power is necessary even if the liquid reaches that side.

Laboratory trials of a number of wetting agents made it clear that, except at uneconomic concentrations, most of them would be inferior to soft soap at 5 lb. per 100 gallons (0·5 per cent.). As there was no particular objection to the use of soft soap all further trials were made with nicotine and soap at various concentrations—though some trials included other materials for comparison. In these field trials it was found that the best results were obtained with nicotine at 8 oz. per 100 gallons (0·05 per cent.) and soft soap at 8 lb. per 100 gallons (0·8 per cent.). At this high concentration of soap wetting was so much improved that the extra cost was largely offset by the decrease in the amount of spray used to cover the plant. Continued trials showed that the aphis could be very well controlled but that too much depended upon the method of application and the time spent at each plant. In commercial

practice for instance, the control is not so good as when the spray is used experimentally. It does however give a very good control and if the aphis were not a virus transmitting species no better result would be needed.

As it seemed impossible to achieve complete control of the aphis by further increase in the wetting power of the spray attention was next given to improving methods of application. In collaboration with Mr. J. Turnbull of the Ministry of Agriculture, a thorough investigation was made of different types of spray nozzles, methods of holding the lance and spraying pressures. It was concluded that complete wetting of every leaf was impossible except at inordinate cost in time and wash.

This result led to the consideration of atomized sprays of pyrethrum extract in oil. It was thought that a fine mist of spray might reach the aphides where a wet spray would not. At first large multiple nozzles were used in the hope that the mist of insecticide would hang round the plants and penetrate among the leaves. This was not possible at any time of day as there was always enough wind in a strawberry field to carry the mist away before it did any good. Even at a time of dense fog, when the air appeared not to move, the spray drifted rapidly away. Evidently it was necessary to cover the plants in some way so that the mist of spray should remain in contact with the plant, and in fact by blowing the spray under a large sheet which covered several rows of plants the result was improved very considerably.

The insecticide first chosen for atomized spraying was an extract of pyrethrum, using an oil of the kerosene type as a carrier. In a series of experiments no control was obtained with a total pyrethrin content of less than about 0·26 per cent. In one case a spray containing this amount of pyrethrin gave a result after two applications about equal to that obtained with one application of nicotine and soap at 8 oz. and 8 lb. per 100 gallons. A pyrethrin content of 1 per cent. was used in one trial with no better results.

The kerosene type oils used as carriers for the pyrethrum extract caused surprisingly little injury to strawberry foliage. In the case of the two (fairly heavy) applications mentioned above slight bronzing of the leaves developed but no scorching or killing of the leaf tissue. No other injury was noted even when a sample of " household paraffin " was used as a carrier in extremely hot weather.

The difficulty of controlling the aphis by means of pyrethrum extract suggested that an atomized spray containing nicotine might be better. Nicotine, being cheaper, could be used at higher concentration than pyrethrum and has the additional advantage that the liquid deposited on the leaves would give off nicotine vapour which might kill aphides not actually wetted by the spray. Preliminary trials were carried out with various concentrations of nicotine and a 10 per cent. solution appeared to give a complete control. This was the first time that a complete eradication of aphis had been found possible with any spray, but the cost of 10 per cent. nicotine was prohibitive. If less liquid was used the results were not so good but a heavier application of spray containing less nicotine was more hopeful.

The use of an atomized spray containing nicotine is of course very dangerous to the operator and unless some safe method can be devised it could not possibly be a practical spray. It is hoped however that this difficulty may be overcome and attention is being paid to this and to questions of quantity and concentration of spray. At the moment the best method of controlling strawberry aphis is still a wet spray of nicotine (8 oz.) and soft soap (8lb. per 100 gallons).

Other methods investigated during this work were the burning of straw litter after fruit picking, which killed off probably 50 per cent. of the aphides when done

under suitable conditions, and the use of repellants against the winged generation. It is hard to say what will or will not repel an aphis but of the materials chosen none had any repellent action.

A bulletin for growers giving the best possible methods for control of Strawberry Aphis on a commercial scale is published on page 250 of this Report.

Strawberry Tarsonemid Mite.

The difficulty of controlling the Strawberry Mite in the field is also due to imperfect wetting by the spray, but it is a rather different problem from that of wetting the aphis. The mites live in the very youngest leaves which are just growing up from the crown and have not begun to open. At this stage each leaflet is folded along the midrib and the two halves are pressed so tightly together that a spray liquid cannot penetrate between them. The difficulty is increased by the upright position of the leaf, and by the fringes of fine hairs on the edges of the leaflets. A liquid may wet the outside of the leaf perfectly without reaching the mites on the hidden upper surface of the leaf. A suitable liquid must not only wet the surface against which it is directed, but must " creep " into places where sheer force cannot drive it, and, owing to the upright position of the leaf, it must do this quickly before the " run-off " reduces the available liquid to a thin film only sufficient to cover the outside of the leaf.

Preliminary experiments on the control of strawberry mite showed that it was susceptible to lime-sulphur but with ordinary methods and concentrations no control was obtained. Small scale field trials were then carried out with :—

Lime-sulphur	1, 2, 3, 4, 5 and 14 per cent.
Petroleum emulsion ..	2 and 5 per cent.
Paraffin emulsion ..	2, 5, 10 and 50 per cent.
Derris powder	0·1 per cent, with soft soap at 0·5 per cent. and 1 per cent.
Liver of sulphur ..	0·2 per cent. with soft soap at 1 per cent. and 2 per cent.

The liver of sulphur spray with 2 per cent. soap gave a partial kill but none of the other materials killed any mites even when the plants were damaged, as with 14 per cent. lime-sulphur which was included accidentally for 7 per cent. This work confirmed the fact that lack of control was due to imperfect wetting so a laboratory trial was arranged in which single plants were sprayed and individual leaves were dipped for some time in solutions of various wetting agents kindly supplied by Imperial Chemical Industries Ltd., under the following names :—Agral N, Agral I, Agral II, Lissapol A, Lissapol C, Fixanol and Agral AX. These were compared with sulphonated lorol and soft soap. All were used at 1 per cent. which is much above the concentration at which most of them could economically be used. No penetration into the folded leaves was observed, so the problem evidently could not be solved by the use of ordinary commercial wetting agents.

As it seemed so difficult to improve penetration in this way a number of other materials were tried in the laboratory to test especially the effect of other sulphur compounds and of some materials which might act in the vapour phase and so reach the mites where a liquid would not penetrate. These tests were carried out by dipping leaves in the solutions for five seconds. The results are summarized in the following table.

Material.	Concentration.	Wetter.	Result.
Lime-sulphur	3%	Lethalate 0·05%	mites killed in two trials.
Liver of sulphur	0·2%	Lethalate 0·05%	no kill.
Ammonium polysulphide	3%		partial kill.
,, ,, ...	3%	Soap 1%	mites killed.
,, ,, ...	3%	Lissolamine A 0·1%	partial kill.
Sodium polysulphide	3%		partial kill.
,, ,, ...	3%	Soap 1%	partial kill.
,, ,, ...	3%	Lissolamine A 0·1%	no kill.
H_2S water (saturated)			partial kill.
,, ,, ...		Soap 1%	partial kill.
,, ,, ...		Lissolamine A 0·1%	no kill.
A 40% dispersion of sulphur ..	2%		no kill.
Pyridine	0·1%	Lethalate 0·05%	mites killed in one trial.
,, ...	0·05%	Lethalate 0·05%	no kill.
Nicotine	0·1%	Lethalate 0·05%	mites killed.
,, ...	0·05%	Lethalate 0·05%	no kill.
Nicotine oleate	1%		no kill.
Derris powder	0·2%	Lethalate 0·05%	no kill.
Pyrethrum extract emulsified in water. Pyrethrin content approximately 0·15%		Lethalate 0·05%	no kill.
Petroleum emulsion	3%		no kill.
A quick breaking petroleum emulsion			partial kill.
Sodium salt of 3:5 dinitro-*o*-cresol ..	1%	Soap 1%	mites killed (plants injured).
Lauryl thiocyanate 50%	1%	Soap 1%	mites killed.
Monochlornaphthalene	1%	Soap 1%	mites killed (plants injured).
Sekay wax R68		Soap 1%	partial kill.
Iodine in potassium iodide solution ..			no kill.

In these experiments a complete kill was obtained only with lime-sulphur, ammonium polysulphide with soap, pyridine, nicotine and lauryl thiocyanate with soap. Several of these were materials of which the vapour may have had some effect and two had a very high concentration of soft soap, and of course, in all cases the possibility of the liquid reaching the mites was greater than in field spraying. Field trials were started with some of these materials and a partial control was obtained with pyridine at 0·125 per cent., but further trials were not carried out because of the success of the warm water treatment of strawberry runners before planting, and also because of the lack of mites in the field at that time.

It may be of interest to mention here three other methods which were tried. The first was probably not a practical method but gave certain degree of control of the mite. A mixture of quicklime and ammonium sulphate was dusted into the crowns of the plants and shaken down off the leaves. On the moist ground ammonia was given off and presumably was not blown away but remained long enough to diffuse between the folds of the young leaves. The plants were dry and no injury was caused to the foliage. The second method was the use of an atomized spray of oil, of the kerosene type, containing pyrethrum extract giving an approximate total pyrethrin content of 0·12 per cent. No mites were killed, even on plants which were sprayed for so long that a wet film of oil was visible on the plants. A cover was placed over the plants during the spraying. The third method was the use of derris powder and soft soap. During August all plants in a greenhouse were sprayed with derris and soap to get rid of insects no longer required for experimental purposes. Some strawberries

infested with mites were included as a precaution, without any expectation of killing the mites. A week later however the plants, which had remained stunted for months, were noticed to be growing rapidly and on examination dead mites were found. This led to a trial in the field in which derris powder was used at 2, 1, 0·5 and 0·25 per cent. with soft soap at 1 and 0·5 per cent. Infested plants were limited but a block of forty was found and each concentration was applied to four plants with a knapsack sprayer. Spraying was very thorough, four gallons being applied to the 32 sprayed plants (equivalent to approximately 1,250 gallons to the acre). In spite of ideal conditions no control or growth of the plants was noted in the following six weeks.

In the course of work on the control of Strawberry Tarsonemid Mite the problem was approached from another angle—that of starting with clean runners and planting in isolation from existing infested strawberry beds. This end was achieved by treating the runners with warm water before planting. This method, which is fully described elsewhere* so effectively disposed of the mite in most seasons that work on the control in the field was suspended and present work aims at improving the treatment of runners to avoid the undesirable check in growth of the plants which occurs if the present warm water treatment is not carefully carried out.

Summary.

Experimental attempts to control *Capitophorus fragariae* Theo. and *Tarsonemus pallidus* Banks are described.

Nicotine and soft soap spraying is the best control for *C. fragariae*. The reasons for its failure to give a complete control were studied but no improvement was found possible.

Atomized spraying with pyrethrum extract in oil was no better, but 100 per cent. control was achieved with an atomized spray containing nicotine. This is too dangerous for practical use but methods of handling are being studied.

Dusts were useless and no substance was found which would repel the winged migrants.

A brief outline is given of work done on the field control of Tarsonemids before this method was discarded in favour of the treatment of strawberry runners before planting. A number of wetting agents and 21 insecticidal materials were used.

* Massee, A.M., East Malling Res. Sta. Misc. Pub., No. 14, 1936, 1-3.

THE BRAMBLE SHOOT-WEBBER*

(*NOTOCELIA UDDMANNIANA* L.)

By G. H. L. DICKER
Ministry of Agriculture Research Scholar

Introduction.

Notocelia uddmanniana is a species of the family Tortricidae, and thus closely allied to the important apple tortrix moths, *Argyroploce angustiorana* Haw. and *Cacoecia podana* Scop.

As long ago as 1910, Theobald (4) found the caterpillar damaging the tips of young loganberry canes in Kent, and since that date it has been reported by many economic entomologists (1, 2). In fact, since 1930 hardly a year has passed when the caterpillar was not mentioned in the May or June Monthly Summary of Insect and Allied Pests issued by the Ministry of Agriculture and Fisheries.

The sluggish, dull brown caterpillar has been found only on plants of the genus Rubus—raspberry, Loganberry, Phenomenal Berry, wild and cultivated blackberry, etc. On these plants it weaves a characteristic web, and this habit has provided the popular descriptive name " Bramble Shoot-Webber " (2).

The moth has often been taken by collectors in many parts of the British Isles, and according to Meyrick (3) is a cosmopolitan species. It has been found throughout Europe to Syria and North Persia, and also in North Africa. Until recently, however, very little appeared to be known about the life history and habits of this species. During the past three years, a detailed study has been made at East Malling, and though no effective control measures have yet been devised the behaviour of the insect in all stages is now well known.

Economic Importance.

In England the Bramble Shoot-Webber is not uncommon on cultivated varieties of Rubus in the main fruit-growing areas—Cambridge and Wisbech, South-East England and the Wye Valley. So far it is only in the first named district where the caterpillar of this moth causes serious damage. Sometimes it appears in sufficient numbers to cause anxiety to fruitgrowers in other localities. This is particularly true of Kent and Sussex, and enquiries are often received from growers about the dirty, brown caterpillar webbing together the leaves at the tips of young canes of Loganberry and Phenomenal Berry.

No appreciable damage is caused by the caterpillar before it hibernates in August. From the time of hatching until the winter resting stage is reached the caterpillar does not exceed half a centimetre in length and confines its feeding activities mostly to a single leaf, living between the two upper halves which are tied together by fine silken strands. On emergence from hibernation in April the caterpillar immediately starts feeding, and it is from now until the chrysalis stage in June that serious damage is done.

The growing caterpillars feed voraciously, those on the fruiting canes destroy the blossom buds, then, when no more young leaves are produced on the fruiting canes they move off to the young canes. Others go straight to the new canes from hibernation. Without exception, the terminal buds of webbed canes are destroyed and growth checked,

* A more detailed account is to appear shortly in *The Annals of Applied Biology*.

to be continued later by the premature bursting of the lateral buds near the tip of the shoot which normally remain dormant until the following spring. The canes with much lateral growth are weaker than single, stout canes ; they also ripen less successfully in the autumn, and consequently there is a reduction in the yield of fruit the following year.

Life History.

The Moth (Fig. 4) is one of the most easily recognized of the numerous species of Tortrix moths. The fore-wings are light brown or tinged with olive-green, and have a distinctive, rounded-triangular, reddish-brown spot towards the outside of the hind edge. The hind-wings and the body are greyish-brown. When fully expanded the wings measure 15 to 20 mm. from tip to tip.

Moths first appear towards the end of June—the earliest records for the past three years are 21st June, 1936, 27th June, 1937 and 25th June, 1938—and may be found until the end of July or early August. During the daytime they are inactive and remain at rest on the underside of a leaf. When disturbed, however, they dart off with a quick, but erratic flight, seldom travelling more than a few feet then alighting again on a leaf or on the ground. In a Loganberry plantation the chances of finding adults are remote unless a very intensive search is made. The most likely time to see the moths is late in the evenings when they are sometimes attracted by light and enter a house. Moths live for nine to fifteen days, and during this period lay over 200 eggs.

The eggs (Fig. 5) are minute, measuring about half a millimetre in diameter. They are translucent white, circular or oval, with a much pitted shell, and not unlike those of the Codling Moth. Eggs are laid singly on the upper or lower surface of a young leaf near the tip of a new cane. When deposited on the upper surface, the position chosen is always in a depression directly above one of the veins ; on the underside there is no favourite spot. In the photograph, the numerous eggs were laid by moths in captivity, and this should not be confused with only one egg laid on each leaf in the field. Hatching takes place thirteen to eighteen days after the eggs are laid, the young larvae emerging through a narrow slit just above the lateral margin.

The Caterpillar. Shortly after hatching the caterpillar is white, with a dark brown head, and approximately one millimetre in length. By the third day a yellowish

Fig. 1.
Drawing of first stage caterpillar. Magnified 75 times.

tinge has appeared in the body colour, and this increases in intensity until in the fully developed first stage the caterpillar is orange brown and measures 2 mm. Thirteen to twenty days after hatching the caterpillar moults, and also changes colour ; the orange tinge disappears and the whole body becomes light brown with the head still dark brown or black. One more moult usually occurs in the summer, eight to thirteen days after the first. The caterpillar is now dark brown with a black head, and this colour remains

constant until it changes into a chrysalis. Soon after the second moult, or very occasionally before, the caterpillar ceases feeding and wanders down the cane to search for suitable winter quarters in which to hibernate. The position chosen is illustrated in Fig. 2. It is between the base of a leaf stalk and the bud or cane. A slight groove is excavated in the cane and a tough silken web spun around the outside; the interior is covered with a finer silky lining.

Sometimes the caterpillar finds a sheltered position under a piece of dead rind instead of near a bud. It is during August when hibernation begins, the actual date depending on the time of egg laying. Between seven and eight months are spent in hibernation, those caterpillars which had not moulted twice before the cessation of feeding in August moult soon after constructing their winter cocoon, so that all are in the third stage when feeding begins again in the spring.

Table I and the graph (Fig. 3) show the period over which the caterpillars leave their hibernating cocoons and recommence feeding. These records were obtained from a plot of mixed loganberries and phenomenal berries, where numerous moths had been released the previous July in order to obtain data in 1938. During the previous year fewer caterpillars were available on potted plants used for egg-laying observations. All lateral shoots of the old and young canes were inspected on alternate days, and any caterpillars found were counted and removed. The figures thus give the total number emerging from hibernation over two-day periods.

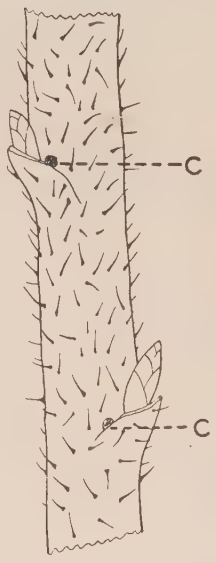

Fig. 2.
Drawing of loganberry cane to show position of hibernation of the caterpillar.
C. Hibernating cocoon.

In 1937, 4th April was the first date when a caterpillar was seen; within ten days 75 per cent. had left their winter quarters. Sixteen days after the first larva appeared 90 per cent. were feeding. The spring of 1938 was notable for the very warm March, and it is possible that these favourable conditions were responsible for an earlier emergence from hibernation than in 1937. The first record in 1938, 28th March, is a week earlier

Table I.

Emergence of *N. uddmanniana* L. Caterpillars From Hibernation; Counts Made at Two-day Intervals.

Date.	1937	1938	Date.	1937	1938	Date.	1937	1938
26th March	—	—	9th April	—	25	23rd April	—	1
27th	—	—	10th	18	—	24th	2	—
28th	—	3	11th	—	18	25th	—	1
29th	—	—	12th	13	—	26th	1	—
30th	—	8	13th	—	12	27th	—	—
31st	—	—	14th	7	—	28th	2	—
1st April	—	13	15th	—	7	29th	—	—
2nd	—	—	16th	6	—	30th	1	—
3rd	—	25	17th	—	3	1st May	—	—
4th	1	—	18th	5	—	2nd	1	—
5th	—	30	19th	—	2	3rd	—	—
6th	8	—	20th	2	—	4th	—	—
7th	—	29	21st	—	1	5th	—	—
8th	20	—	22nd	2	—			

than in the previous year. Again the graph shows a rapid rise in the number emerging for the first week or ten days, then an almost as rapid decline until only one or two fresh caterpillars appear at each inspection. This latter condition persisted for a fortnight in 1937, but only just over a week in 1938. The percentages show very similar results for the two years. In 1938, 75 per cent. are again feeding by 9th April, a fortnight after the first emergence, and 90 per cent. after eighteen days. Thus at East Malling 90 per cent. of the hibernating caterpillars of the Bramble Shoot-Webber are again feeding early in the third week of April. This will be an important point in deciding when to apply control measures, as the only period in the life cycle when a spray can be used effectively appears to be immediately after hibernation.

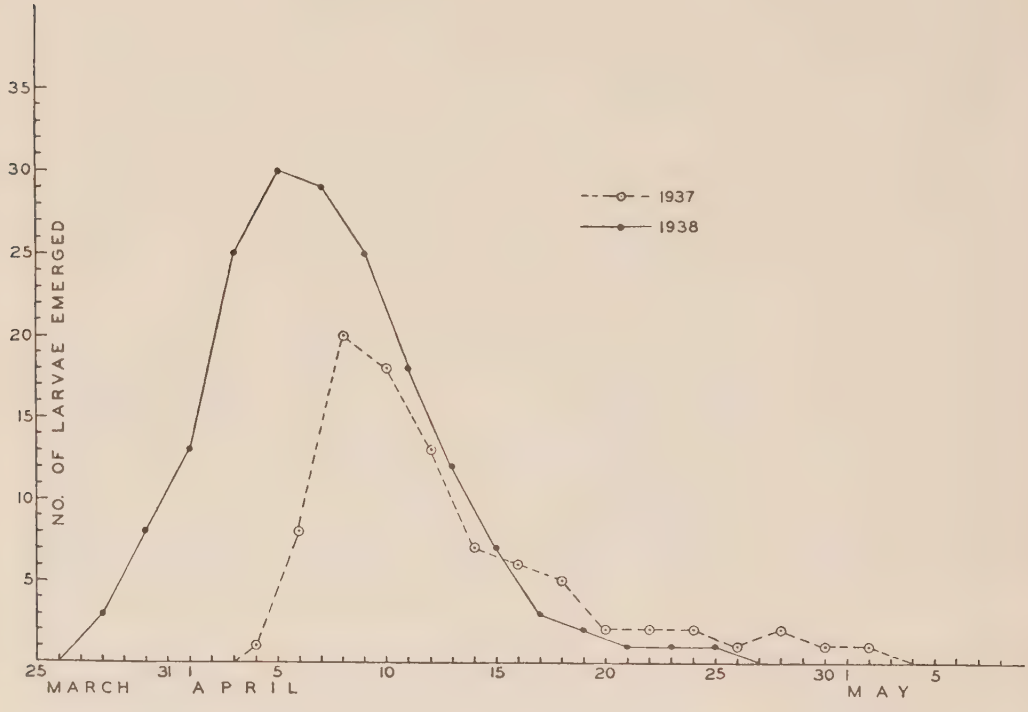

Fig. 3.

Graph to illustrate the emergence from hibernation of *N. uddmanniana* caterpillars.

The caterpillar emerges from the winter cocoon by biting a small round hole just sufficiently large to allow its body passage to the outside.

The caterpillar is now about 5 mm. long, and continues to grow rapidly. Two more moults occur, the first approximately sixteen days after leaving hibernation, then another from three to four weeks later. Another month elapses before the chrysalis stage is reached. When fully fed, the caterpillar is dull brown, somewhat sluggish and measures up to 1·5 cm. in length.

The chrysalis is reddish-brown, always darker on the upper surface and nearly 1 cm. in length. Individual specimens show a marked difference in colour intensity, varying from almost black to chestnut brown. For a period of about three days prior

to pupation the caterpillar does not feed. It becomes paler, sluggish and wrinkled. The caterpillar spins a small silken web around itself within the webbed mass of leaves and here changes into a chrysalis. By no means all stop feeding at the same time. The first chrysalis is found during the last week in May, but some larvae are still present until the end of June. This stage lasts for seventeen to twenty-eight days, then the moth hatches out and the life cycle begins again.

Feeding Habits.

On hatching the young caterpillar immediately migrates to the growing point of the cane on which the egg was laid. Here it crawls between the two halves of a slightly opened leaf, and by means of silken strands webs the two halves together. Both first and second stages are commonly found in this position. As the leaf develops, and becomes tougher, the caterpillar moves up the cane to a more tender leaf, treating it in a similar manner. Before the hibernating phase is reached most of the caterpillars have ceased to inhabit a single leaf and have burrowed into the actual growing point of a cane. At this period they are so small that no harm to the plants results from their feeding.

When hibernation takes place in August, the caterpillar is on the current year's cane ; on emerging in the following April it is on the fruiting cane of that year, since most of the cultivated forms of Rubus produce canes which fruit in the second year and then die. Some caterpillars feed on the fruiting laterals of this cane, at first webbing together leaves, then, when the blossom buds appear, they tunnel into the centres of the buds, eat the interior, and leave only a shell composed of sepals and petals.

In April, others leave the old canes on which they spent the winter and wander on to the young canes, which by this time are only a few inches above soil level. Here the two halves of a young leaf are webbed together, or two overlapping leaves may form the initial habitat. As the cane grows and more leaves open, the web is enlarged to encircle these leaves, until finally the whole shoot-tip is tightly drawn together with the terminal bud completely hidden (Fig. 6). Caterpillars still use the older leaves as a shelter, making excursions to the tender leaves and bud for food.

Those caterpillars on the fruiting laterals do not often remain after blossom buds have reached an advanced stage and no more young leaves are being produced. Instead, they move on to the young canes, webbing together the leaves around the growing point just as those caterpillars did which migrated immediately on emergence from hibernation.

Except when the infestation is severe, not more than one caterpillar is found in a web. The limiting factor to this type of solitary existence is reached when the caterpillars outnumber the new canes. Then it is quite common to find as many as three or four living together in the same web. Normally a caterpillar lives in the same web on a new cane until the chrysalis stage.

Host Plants.

Of these varieties of Rubus most widely grown, only the Loganberry and Phenomenal Berry suffer severely from attacks by this Tortrix caterpillar. Raspberry, and the cultivated blackberries (Himalaya, Black Diamond and the Cut-leaved) appear far less attractive as food plants, yet a small number of caterpillars are present on them each year. The numerous other species and hybrids of Rubus all provide an adequate food supply for *Notocelia uddmanniana* L. to complete its life cycle, but none has been noticed heavily infested.

Wild blackberry is most definitely a favourite host plant, and the webs with caterpillars inside them may be found on almost any large clump of brambles in South-East

England. It must be borne in mind, when planting up Loganberries in a district where this insect is a pest, that grubbing old plantations nearby is not a sufficient safeguard when wild blackberries are growing around the headlands or in neighbouring woods. The presence of wild blackberries is always a potential source of infection. So far this Tortricid has been found feeding on no plant other than a species of Rubus, and hence appears to possess a very limited range of food plants.

Parasites.

Two species of wasp-like parasites and one species of parasitic fly have been bred from the caterpillars of *Notocelia uddmanniana* L.

It is probable that this species of Tortricid is kept in check to a considerable extent by the presence of an Ichneumon parasite, *Omorgus mutabilis* H. Gr. From several hundred caterpillars collected in the East Malling district on both wild blackberry and Loganberry during the past three years, the proportion parasitized has not fallen below 36 per cent. (Table II).

TABLE II.

PERCENTAGE *N. uddmanniana* L. PARASITIZED BY *O. mutabilis*.

Year.	Total No. of larvae collected.	No. of larvae parasitized.	Percentage parasitized.
1936	410	154	37·5
1937	343	123	36·0
1938	375	180	48·0

The adult parasite lays its egg in the young caterpillar, probably while still in the first stage. The full effect of the parasite is not obvious, however, until the Tortrix caterpillar is mature, in June, and by that time, of course, it has done all the necessary damage to the plant. On the other hand, the reduction in number of moths which emerge later in the summer lessens the number of eggs laid, and consequently reduces the infestation the following year.

The first indication that a caterpillar is parasitized is partial cessation of feeding, sluggishness, and the skin becomes a darker brown and wrinkled. A few days later another colour change occurs, this time to a grey-brown, and the parasite maggot may be observed to fill the entire body space of the caterpillar. It breaks through the skin of its host and spins a grey, ovoid cocoon in situ.

This parasite is widespread in England, and has been bred from caterpillars sent in from Gloucestershire, Lincolnshire, Cambridgeshire, Essex, Kent, Sussex and Devon.

The other Hymenopterous parasite which feeds inside the caterpillar has been discovered only in small numbers, and has very little effect in reducing this pest. It is an undescribed species of *Apanteles*.

One specimen of a Dipterous parasite, *Nemorilla notabilis* Mg. (fam. *Tachinidae*), was bred from a chrysalis. The parasite was undoubtedly present in the caterpillar when collected, but it did not appear until after the transformation to a chrysalis.

PRELIMINARY CONTROL MEASURES.

In the past the only means by which the Bramble Shoot-Webber could be reduced was the cumbersome method of picking by hand. Besides the time taken to inspect each side of every plant, there are the additional disadvantages that the caterpillars must be

left until they have caused the damage before becoming sufficiently obvious to be picked, also the whole shoot tip is cut off, completing any damage to the growing point omitted by the caterpillar.

From a study of the life history and habits it seems impracticable to apply control measures to the egg stage or very young caterpillars since the fruiting season has begun. There are two other possibilities :—

(*a*) Applying a winter wash to the canes to kill the hibernating caterpillars.

(*b*) Spraying or dusting after the caterpillars have begun feeding in April.

We can reject the first suggestion immediately. Canes containing hibernating caterpillars were dipped in a 10 per cent. tar distillate wash, but this gave no control. The cocoon in which the winter is spent appears to be impervious to a tar wash.

The main difficulties encountered are the length of time over which the caterpillars emerge from hibernation (Table I, Fig. 3), the habit of the caterpillars to spin a protective web around themselves immediately they recommence feeding, and the rapid growth of the plant.

In the spring of 1937, lead arsenate paste at the rate of 4 lb. to the 100 gallons of water was used on a small scale. It was applied immediately the caterpillars began to emerge from hibernation. Plant growth was so rapid that within two days new leaves could be observed with no spray residue. No difference in infestation between sprayed and control plots could be detected.

A similar experiment was carried out using 2 lb. of a proprietary derris extract, plus 6 lb. of soft soap to a 100 gallons of water. The lack of cover, as occurred with the lead arsenate after a few days, had been anticipated, and it was hoped the derris remaining on the older leaves would have a possible residual, contact, toxic action. With one application when the first caterpillars were seen, and another ten days later no control was obtained.

In 1938 an atomized pyrethrum spray was used experimentally as a possible means of control. Using a hand atomizing unit and a pyrethrum extract of known composition diluted to a strength of 0·5 per cent. pyrethrins content, in a base of highly refined white oil of the kerosene type (with a viscosity of 30° Saybolt at 100° F. and 99 per cent. insoluble in concentrated sulphuric acid), good results were obtained. On 4th April before all the caterpillars had left their winter cocoons, twenty plants were sprayed. A count on the following day showed that out of forty-two caterpillars, forty were dead, one was obviously unhealthy and died afterwards, and the other survived. A field trial was arranged and after many difficulties, finally completed on 6th May. By this time all the caterpillars were surrounded with large webs and penetration of the spray was undoubtedly impeded. The experimental spray, reduced to 0·25 per cent. pyrethrins content, gave a control of 6·5 per cent. and a proprietary spray* of unknown composition 3·7 per cent. each on plots of one-third of an acre.

Since the earlier trial gave such promising results it will be necessary in 1939 to continue with a pyrethrum spray on a field scale, but at a much earlier date than in 1938.

Summary.

The life history and habits of the Bramble Shoot-Webber, *Notocelia uddmanniana* L., have been studied over a period of three years.

This Tortrix is of economic importance in certain fruit-growing areas.

* The writer is indebted to Mr. J. V. Lewis of Messrs. Strawson, Ltd., who kindly loaned the atomizing unit and provided the proprietary spray.

Two species of Hymenopterous parasites, *Omorgus mutabilis* H. Gr. (Ichneumonidae), and an undescribed species of *Apanteles* (Braconidae) and one Dipterous parasite, *Nemorilla notabilis* Mg. (Tachinidae), have been bred from the larva.

Preliminary control measures using lead arsenate and Derris have yielded poor results, when applied in April during the period of emergence of the caterpillar from hibernation.

Atomized pyrethrum, applied at the same period, gave excellent results on a small scale, but a field trial in early May proved disappointing.

Acknowledgements.

The writer wishes to acknowledge his thanks to Dr. A. M. Massee under whose supervision this work has proceeded, for the many useful suggestions and the constant interest in these studies.

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FIG. 4.
Moth of *Notocelia uddmanniana* L. Magnified $2\frac{1}{2}$ times.

FIG. 5.
Eggs of *N. uddmanniana* L. Magnified 4 times.

FIG. 6.
Leaves of young blackberry cane webbed together by the caterpillar of *N. uddmanniana* L.

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INSECTICIDES AND FUNGICIDES

SPRAY RESIDUE INVESTIGATIONS

III. THE INFLUENCE OF PETROLEUM OIL AND OF LIME-SULPHUR ON THE RETENTION OF LEAD ARSENATE ON APPLES

By H. SHAW and W. STEER

A SPRAY residue trial in 1937, undertaken in connection with Codling Moth control, led to the conclusion (1) that the addition of oil to a lead arsenate spray increases the deposition and retention of arsenical residue on apple fruits, and that the addition of a wetter or of lime-sulphur or of both has no measurable effect.

In 1938 a closer study was made of the effect of the addition of oil and of lime-sulphur. A trial that differed in several respects from that of the previous season was carried out. Apples of the variety Edward VII had to be used because the crop on Cox's was insufficient for the purpose ; the size of the trial was increased to three blocks of single tree plots of each treatment in place of the two blocks previously used ; the number of times of sampling was increased from three to four ; the trial was designed to permit estimation not only of the effect of oil and of lime-sulphur, but also of any possible differential effect of the two in combination.

The materials used were

A. *Lead arsenate paste* containing 15-16 per cent. arsenic pentoxide, at 0·4 per cent.

LS. *Lime-sulphur solution*, sp. gr. 1·3, polysulphide sulphur (by weight) approximately 20 per cent., at 0·75 per cent.

Oil. *Shell oil* 24413 emulsified with sulphite-lye, at 1 per cent. oil,

and the combinations selected for investigation

1. **A.**
2. **A.Oil.**
3. **A.LS.**
4. **A.LS. Oil.**

The four treatments were arranged at random in a row of bush trees so that each spray was applied to three trees, one in each of three blocks. As samples of fruit were taken on four occasions the sampling dates had to be regarded for statistical purposes as sub-divisions of the main plots. An unavoidable result of this split-plot treatment is that the effect of spray materials and of lapse of time cannot be measured with equal precision.

The trees were sprayed on 2nd July in as uniform a manner as possible. A moderately fine spray was used and care taken to apply similar amounts of each wash.

The deposit from lead arsenate alone was fairly evenly distributed whereas with oil it was less even, but adhered in larger drops. The addition of lime-sulphur to either spray seemed to improve the evenness of distribution.

Sixteen days later severe spray damage had developed. Wherever lime-sulphur had been included most of the older leaves turned yellow. The damage was even more severe on the **A.LS. Oil** plots, where heavy leaf-fall also had occurred. The damage increased during the next few days, when leaf-drop from **A.LS.** occurred, but remained worse on **A.LS. Oil.** The other treatments, **A.** and **A. Oil.**, caused no obvious damage. It must be admitted that isolated observations during the last few years suggest that the type and extent of spray injury experienced in this plantation are often unusual.

Showers of rain on the days immediately following spraying delayed the collection of the first sample of fruit until 6th July, four days after spraying, when two random samples, each of 15-17 fruits and weighing about 400 g., were taken from each tree. Further samples were collected on 25th July (10-12 fruits, about 500 g.), 15th August (6-8 fruits, about 600 g.), and at picking time, 29th September (6 fruits, about 900 g.).

The weight of arsenic in each sample was determined by duplicate analyses according to the method previously described (1). The mean weight per sample for each tree was then calculated from the pairs of samples. The figures in the body of the following table are each the mean of three trees.

TABLE I.

EDWARD VII (1938): PARTS As_2O_3 PER MILLION (MG. PER KG.).

Sampling Date.	A.	A.Oil.	A.LS.	A.LS.Oil.	Means.
6th July	6·84	8·48	8·29	6·79	7·60
25th July	3·18	3·46	3·11	3·68	3·36
15th August	1·28	2·02	1·68	1·45	1·61
29th September	1·10	1·29	1·09	1·35	1·21
Means	3·10	3·81	3·54	3·32	

These figures suggest that oil increased the arsenical deposit, but, possibly, only in the absence of lime-sulphur. No treatment effect, however, was significant at a probability level of 0·05.

The evident inconsistencies may have arisen from chance differences in the size of the fruits or from different rates of growth. The data relating to size of fruit were therefore examined and are summarized in Tables II and III.

TABLE II.

EDWARD VII (1938): FRUIT SIZE—MEAN WEIGHT PER FRUIT IN GRAMMES.

Sampling Date.	A.	A.Oil.	A.LS.	A.LS.Oil.
6th July	48·4	52·0	46·9	47·5
25th July	95·9	102·4	88·9	78·6
15th August	191·3	198·1	167·8	160·0
29th September	306·2	327·0	277·2	268·6
Means	160·4	169·9	145·2	138·7

TABLE III.

EDWARD VII (1938): EFFECT OF LIME-SULPHUR.

Sampling Date.	Without LS.	With LS.	Difference due to LS.
6th July	50·2	47·2	− 3·0
25th July	99·1	83·7	−15·4
15th August	194·7	163·9	−30·8
29th September	316·3	272·9	−43·4
	Significant Difference = 15·0		
Means	165·2	141·9	−23·3
	Significant Difference = 14·8		

Judged by the *z* test, the only significant treatment effect was that of **LS.** versus **no LS.** and the only significant interaction was the differential effect of dates of sampling and **LS.** The check to fruit growth caused by lime-sulphur is evident in the second sampling; in the later samplings the actual differences in fruit size are greater but the relative differences remain the same, showing that after the initial check the **LS.** fruits grew at the same rate as the rest.

Since fruit size may be affected more by some sprays than by others, any expression involving a weight of fruit, e.g. parts per million, is open to serious objection. The data are better presented as mg. per 100 fruits, an expression independent of fruit size. This form is adopted in Table IV.

TABLE IV.

EDWARD VII (1938): MG. As_2O_3 PER 100 FRUITS.

Sampling Date.	A.	A.Oil.	A.LS.	A.LS.Oil.	Means.
6th July	17·0	22·0	19·0	15·7	18·4
25th July	14·7	17·3	13·7	14·3	15·0
15th August	12·3	20·3	14·3	11·7	14·7
29th September	17·3	21·0	14·7	17·0	17·5
	No significant differential effect.				Significant Difference =2·1
Means	15·3	20·2	15·4	14·7	
	Differences not significant.				

No treatment effect was significant at a probability level of 0·05, but the results suggest that oil increased the deposit.

Although the treatment means could not be shown to differ, some quite small differences associated with date of sampling were significant. It is inconceivable, however, that the deposit could be heavier at the final sampling than at the second or third, and the apparent significance suggests that the sampling or the analytical method used was inadequate.

Realization of the effect of differences in the rate of fruit growth prompted a re-examination of the data of the 1937 trial. These are now expressed (Table V) as mg. As_2O_3 per 100 fruits.

TABLE V.

COX'S ORANGE PIPPIN (1937): MG. As_2O_3 PER 100 FRUITS.

Sampling Date.	A.LS.Leth.	A.LS.	A.	A.Leth.	A.Oil.	Means.
15th July	7·0	7·0	8·5	8·0	10·5	8·2
5th August ..	6·5	8·0	8·5	7·5	17·0	9·5
23rd August ..	8·0	8·5	8·9	6·0	15·0	9·1
	No significant differential effect.					Differences not significant.
Means	7·2	7·8	8·3	7·2	14·2	
	Significant Difference = 2·7					

The effect of spray treatment was highly significant and the conclusions drawn in 1937 (1) were evidently well-founded as regards the effect of oil on the deposition of lead arsenate. Neither the effect of date of sampling nor the interaction of dates and treatments was significant. It must be inferred, therefore, that little or no loss of deposit is caused by weathering.

It now seems that the methods used in these trials were just adequate to give significant results on Cox's, but scarcely adequate to do so on Edward VII, a variety of different habit.

There is little doubt, however, that the addition of oil to lead arsenate increases the amount of arsenical deposit, but the effect of lime-sulphur is not yet clear. There is no evidence that the persistence of the deposit is affected either by the constituents of the wash or by weathering. Any progressive reduction in amount of residue in relation to weight of fruit can be accounted for by attenuation due to growth of the fruit.

The relation of increasing size of fruit to decreasing amount of residue is demonstrated in Fig. 1.

SUMMARY.

The investigation of the effect of additions to a lead arsenate spray was continued in 1938. Oil appeared to increase the arsenical residue except, perhaps, where used with lime-sulphur. Lime-sulphur by itself had no effect.

Fruit growth was checked wherever lime-sulphur, with or without oil, was used. For this reason weight of residue per 100 fruits proved better than weight per weight of fruit as a basis for consideration of the results.

The apparent loss of residue, in terms of mg. As_2O_3 per Kg. of fruit, was accounted for by attenuation due to fruit growth. No evidence was obtained of actual loss by weathering.

ACKNOWLEDGEMENT.

The authors are indebted to their colleagues Messrs. T. N. Hoblyn, and S. C. Pearce, for help and advice in the statistical examination of their data.

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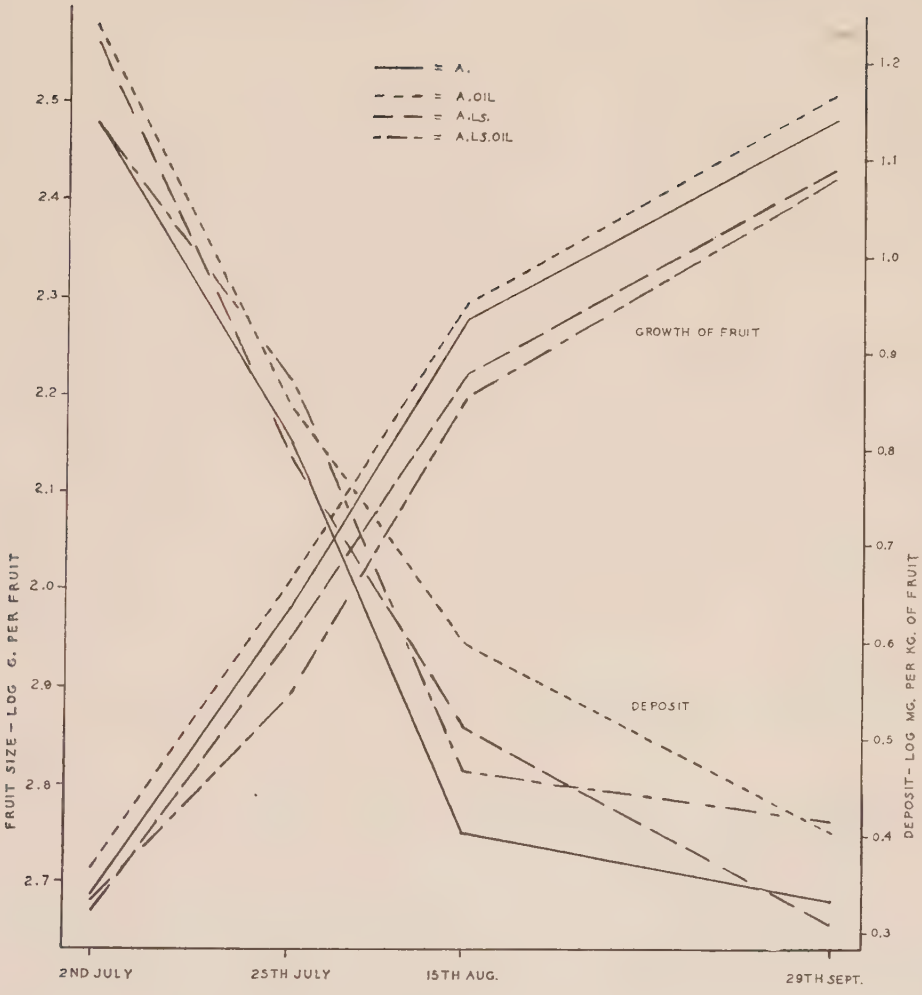

FIG. 1.
Relation of arsenical deposit to growth of fruit.

Section IV

BULLETINS FOR FRUITGROWERS

POMOLOGY

MANURIAL EXPERIMENTS WITH APPLES AND PEARS AT EAST MALLING, 1919-38*

By W. A. BANE

Preliminary Experiments with Apples.

In 1919 a block of Bramley's Seedling and Worcester Pearmain on eight rootstocks was planted in Great East Field *on land in good heart*, as part of the main rootstock trials. It was decided to carry out a preliminary manurial experiment on these trees, one acre remaining unmanured except for the ploughing in of non-leguminous green crops, while the adjoining acre was to be manured in accordance with the general practice of the day in Kent. This meant that nitrogen and phosphorus were to be applied in the form of bulky organics such as dung, shoddy, and meat and bone meal. Potassium in the form of muriate was applied in the winter of 1924-5, and sulphate of potash was applied yearly commencing with the winter of 1926-7.

During the first six years of that experiment the trees on the unmanured acre grew quite as strongly as those which received manure, which seems to show that healthy young apple trees planted on land already in good heart, can grow away and make strong trees in early years without the aid of heavy dressings of bulky nitrogenous manures.

Later the unmanured trees fell behind, and by the end of the eleventh season when the experiment came to an end they were growing much less vigorously than those which had received manure. The effect of the manuring was also visible in higher yield and in larger fruit. These differences gave a definite measure of the response which apple trees will make to that type of manuring over a ten-year period and showed also that such response varies both with variety and with rootstock. The experiment gave no definite information as to the parts played by nitrogen, phosphorus and potassium in producing this response in the trees and it was decided to plan a large-scale experiment to supply this information.

Effect of Nitrogen and Potassium on Starved Trees.

Before describing that experiment, however, the subsequent history of the Bramleys and Worcesters in the original "starvation" acre plot should be mentioned. After eleven years of starvation the trees looked thoroughly unhealthy, the leaves being thin and of a pale sickly green colour, and many trees suffering badly from leaf-scorch. It was decided to see what could be done to restore these trees to a normal state of

* Reprinted from *Scientific Horticulture*, 1939, **7**, 45-9, by permission of the Editor.

vigour by applying nitrogen and potassium both singly and in combination in fairly heavy dressings. There were four treatments :—nitrogen alone, potassium alone, nitrogen plus potassium, and nil, nitrogen being applied in the form of sulphate of ammonia at the rate of 4 cwt. per acre, and potassium in the form of sulphate of potash at the rate of 4 cwt. per acre for the first year, and 8 cwt. per acre in subsequent years. The results showed that heavy dressings of potassium resulted in a remarkable recovery first of the Bramley's Seedling and later of the Worcester Pearmain. It was found that potassium increased the amount of shoot growth, the crop, and the size and quality of the fruit, while nitrogen increased the girth of the tree, and restored the normal green colour to the leaves but had a rather bad effect on the size and colour of the fruit. The best results were obtained in Bramley's Seedling from the combination of nitrogen and potassium but in the Worcester Pearmain the fruit was less highly coloured under this treatment than on the trees which received potassium only.

Experiments with Nitrogen, Potassium and Phosphorus.

In preparation for the large-scale experiment mentioned earlier, some three acres of recently acquired land in Church Field were sown to oat and corn crops for four successive years without receiving manure of any kind, the object being to reduce to a minimum the supplies of nitrogen, phosphorus and potassium available in the soil. The field was then planted in 1930 with two-year-old trees of Cox's Orange Pippin and Beauty of Bath raised here on the main groups of rootstocks, No. V being included because it is prone to leaf-scorch due to potash deficiency. The arrangement of the plots was statistically planned to allow for local variations in growth conditions, and guard rows were provided. In this experiment it was decided to apply inorganic fertilizers as long as possible in view of the difficulty of getting organic manures which would be sufficiently uniform in analysis to allow of a just comparison throughout the experiment. Nitrogen, phosphorus, and potassium were applied, singly and in all possible combinations, and there were also unmanured " nil " plots. It was recognized that the trees could not be grown permanently without humus and it was decided to apply it as soon as the trees showed the lack of it, preparing it meanwhile by a process which would give as low a content of nitrogen, phosphorus and potash as possible.

Differences between treatments began to show up very quickly and it soon became clear that under these conditions potassium was the limiting factor to growth. Careful records of vigour and cropping on each tree showed (*a*) that during the first seven years the trees in the plots receiving potash had an average spread of at least one foot more than those on the " no-potash " plots, (*b*) that the crop was double, and in many cases more than double, and (*c*) that the fruit was larger.

Leaf-scorch was noticeably severe on all the no-potash plots. On the various rootstocks there has been a difference in both the severity of leaf-scorch and the response to the potash applications. On the whole, trees on No. IX rootstock have shown less scorch than those on Nos. I and V, both with and without potash. With the exception of one year in five for the trees with potash and two years for those without, Cox's Orange has also scorched less on IX than XII. With these exceptions, trees on XII have been intermediate for scorch. No. I or No. V has in all cases given most scorch. In four out of five years, Cox's Orange was less or slightly less scorched on V than on I without potash and less scorched on I than on V with potash, the reduction in scorch by potash treatment being proportionately more on I than on V. With Beauty of Bath the results are similar but less definite.

During the last two years there has been severe dying back of the branches, especially on the potash-starved trees. Accordingly all plots are now being given a

yearly dressing of 2 cwt. per acre of sulphate of potash and have received it for the past two years. At the same time, the wetness of the soil in winter, coupled with clean cultivation for ten years, without any addition of organic matter, suggested that the dying back might be connected with lack of humus in the soil. It was therefore decided to apply to half the plots in the experiment a dressing of humus that had been manufactured on the farm by the " Indore " process from various forms of waste vegetation.

Nitrogen and phosphorus appear to have contributed little to the nutrition of the tree, compared with potassium. There are again indications, however, that the response of the tree varies according to variety and rootstock. Thus in growth in the first five years, Cox's Orange has responded to nitrogen, whereas with Beauty of Bath there has been a detrimental effect. With the two scion varieties considered together phosphorus has had a beneficial effect on the growth with IX in the absence of nitrogen and a detrimental effect in its presence. With Nos. I and V combined the same effect exists but is not significant, whilst with No. XII there is no effect at all.

In the case of nitrogen and phosphate the only large difference in the amount or quality of fruit has been a significant increase in crop of Cox's Orange on V resulting from the nitrogen. Differences in size of fruit and in amount and intensity of colour have been small in comparison with those resulting from potash. With regard to rootstock V, the significant increase in crop of Cox's Orange resulting from nitrogen causes one to consider carefully the question of fruit size and quality, especially as the greatest weight per tree up to 1937 has been given by this rootstock with the potash plus nitrogen treatment. The fruit has been smaller and not so well coloured as on I, but the differences have been small. The effect of increasing the annual dressing of potash from 2 to 4 cwt. per acre remains to be seen. After two years, rootstock No. V still shows more scorch than I and the reduction of scorch as a result of the increase in amount of potash has been proportionally greater with I than with V.

Effect of Nitro-Chalk on Trees in Grass.

A three year experiment was carried out from 1933-5 on some trees of Worcester Pearmain on various Malling stocks, planted in 1919 and grassed down in 1930, the grass being sown right up to the trunks of the trees. The trees on dwarfing stocks showed signs of serious nitrogen deficiency after three years in grass. The objects of the experiment were to see if the nitrogen deficiency could be made good by applying nitro-chalk through the grass, and further to see whether this could best be done by a normal dressing, given annually over a period of years, or whether a quick result could be obtained by giving an extra heavy dressing in one year.

There were two treatments with nitro-chalk : a normal dressing of nitro-chalk at 5 cwt. per acre applied yearly, and a heavy dressing of 15 cwt. per acre given all at the same time. Both treatments resulted in a marked increase in tree girth accompanied by an increase in crop in the first year. The heavy dressing resulted in greater increase in growth, a larger crop, more shoot growth, much darker coloured foliage and the trees held their leaves longer in the autumn than those which received the normal dressing. The effect on the fruit of the heavy dressing of nitro-chalk was very marked. Colour was very poor, the fruit was smaller, and the apples fetched lower prices than those from the trees which had received 5 cwt.

In the second year, 1934, the trees which had received 15 cwt. the year before had nothing, while the others again had 5 cwt. per acre. The results were similar to those of 1933, the fruits from the trees which had the heavy dressing in the previous year being again inferior in quality. In 1935 the frost in May resulted in an almost total loss of crop so that no data were available for that year.

The result of the experiment was to show that very heavy dressings of nitrogen are most unsuitable for Worcester Pearmain, even when the trees are in grass, and that the normal dressing of 5 cwt. nitro-chalk gave good quality fruit with healthy foliage and shoot growth with most rootstocks. Subsequent experience showed that 5 cwt. per acre was not enough for trees on some rootstocks. The quantity now given in any one year is based on the appearance of the trees in the previous growing season and in the spring of the year in question.

Preliminary Experiment with Pears.

In view of the need for more precise data on manuring of pears, a preliminary experiment was begun in 1934-5 on a plot originally used for a rootstock and pruning experiment. The basal dressing given to the whole plot has consisted of 10 cwt. shoddy per acre and 5 cwt. steamed bone flour. In the first year the shoddy was omitted, as a crop of tares had been ploughed in, while in 1936-7 it was replaced by 15 loads of dung to the acre. In addition some trees have each year received sulphate of potash at 4 cwt. per acre, increased to 8 cwt. in 1937-8, and some of these trees have also received sulphate of ammonia. The quantity of sulphate of ammonia has been increased from a first dressing of 2 cwt. to 3 cwt. and finally to 6 cwt. per acre. Up to 1938 there had been no visible effect on foliage of the inorganic nitrogen or of the potash. In 1938 it seems that there has been a slight darkening of the foliage by the nitrogen. The plot as a whole now looks much better and this may be the result of the basal dressing.

Summary.

In a preliminary experiment apples planted on land in good heart and subsequently unmanured grew as strongly as manured trees for six years. Later they fell behind. After eleven years they were thoroughly unhealthy. Fairly heavy applications of nitrogen and potash resulted in a remarkable recovery, a combination of the two giving the best results with Bramley's Seedling and potash alone with Worcester Pearmain.

In a large scale experiment to determine the parts played by nitrogen, phosphorus and potash, the main effect has been that of potash. Differences with nitrogen and phosphorus have on the whole been small.

A three year nitro-chalk experiment with nitrogen-starved Worcester Pearmain trees in grass showed that an annual dressing of 5 cwt. was better than one of 15 cwt. given at the beginning.

In a preliminary experiment on pear manuring there has been no visible effect of potash and inorganic nitrogen, over that of a basal manuring, until the fourth year, when the quantities have been much increased.

RESEARCHES INTO THE CAUSE AND PREVENTION OF FROST DAMAGE*

By C. E. CORNFORD

LATE in the blossoming season of 1935 there occurred cold north winds and a very severe frost which caused great damage to fruit trees in many parts of Europe. East Malling Research Station made a field survey of the damage done to fruit trees in England and called a Conference on Frost Damage in the following September, at which a resolution was passed asking the Ministry of Agriculture to study the cause and prevention of frost damage. The Ministry gave a grant to enable the writer to begin the research under the supervision of a small committee, and with headquarters at East Malling.

The most common type of frost, called a " radiation frost " to distinguish it from a " wind frost ", can only occur at night when the air is calm and the sky is free from cloud. Under these conditions there is nothing to prevent the heat in the ground passing by radiation into inter-stellar space. Hence all soil and plant surfaces exposed to the sky cool. So also does the air in about the first five feet above the ground, for it is denser than the air immediately above it (at say ten to fifteen feet), and so tends to move into the lowest place. On the lower part of a sheltered hillside for example, the relatively cold layer of air near the ground moves downhill and is called a katabatic wind. Katabatic means down-going. Katabatic winds may cause large amounts of relatively cold air to come together on low-lying ground during a radiation night. When the temperature of this air falls below the freezing point of water we say there has been a frost, and because the heat was lost by radiation it is called a radiation frost. In view of these generally accepted facts it was thought advisable to begin this research with a study of the katabatic winds. Some experiments were also made with orchard heaters with a view to finding the best technique to employ when trying to estimate the effectiveness of them. All the experiments mentioned below were made on radiation nights.

KATABATIC WIND AND HILLTOP WIND.

Speed and Direction.

The katabatic winds in Kent move at from 0 to 5 miles an hour. This slow speed necessitated the invention of specially sensitive instruments for recording the speed and direction. Katabatic winds were first studied on a steep slope (1 in 3) which faced south-west on the North Downs in Kent. It was found that on most radiation nights a relatively warm and strong wind was blowing on the hilltop. This wind is called for convenience the hilltop wind and usually it blew from the same direction as the wind that had been blowing during the day, but it was much weaker than the day wind. When the hilltop wind blew from the south-west upon this slope it was observed that as the slope was descended the force of the hilltop wind grew less until a zone was found where the air was still ; below this a katabatic wind was found flowing down the hill. Above

* Reprinted from *Scientific Horticulture*, 1939, **7**, 60-3, by permission of the Editor. Further details are given in an illustrated article by the same author : " Frost and Fruit Growing." *Journ. Min. Agric.*, XLV, January, 1939, 981-91.

the still zone the air moved uphill, below the still zone the air moved downhill. The position of the still zone varied as the hilltop wind varied in strength, the still zone being highest when the hilltop wind was weakest.

When the hilltop wind blew slantwise on the slope, the katabatic wind moved at first slantwise downhill, then straight downhill, and a place could always be found on the slope, between the hilltop wind and the katabatic wind, where the air moved straight along the contours.

Forest trees and shrubs were found to offer little obstruction to the katabatic wind. However, a well-kept beech hedge (seven feet high) at right angles to the direction of a katabatic wind caused the wind to flow over instead of through the hedge. A wall acted in the same way indicating that it is difficult to nullify the harmful effect of a katabatic wind by attempting to alter its course. As shown below, it appears easier to alter its temperature.

Temperature.

The temperature of katabatic and hilltop winds was studied by means of screened minimum thermometers and thermographs placed at three feet above the ground. The first experiment was an attempt to discover the effect of altitude on air temperature. A row of five thermometers spaced at equal distances was placed across the valley of the Medway at Wateringbury, Kent, the central thermometer standing at the bottom of the valley, and the end thermometers on the top of the valley sides 300 feet above the river. The temperature readings of January and February, 1937, showed that on some radiation nights the lowest places were coldest, and temperature increased with altitude, as expected. On one other night, in these same places, when temperatures were all at or below freezing point, the lowest place was warmest and the temperature decreased with altitude. This result was unexpected and difficult to explain. It shows that our knowledge of the weather on frosty nights is not as complete as it might be, and the experiment is being repeated.

Other experiments with thermometers made on undulating but low-lying land near Aylesford, Kent, showed that on almost every frosty night some fields in low places were covered in warmer air than certain fields on higher land, and other fields in low places were covered in colder air than neighbouring fields on higher land. There was, in fact, a mosaic of cold and warm patches of air corresponding to the pattern of the fields but not to hill and valley. This gave a clue to the fact that the vegetation growing in a field may influence the temperature of the air above it on a frosty night. As soon as this was realized, experiments were set up, in May and June, 1937, on level land at East Peckham, Kent, to find out which crops gave rise to the coldest and the warmest air. It was found that meadows and a field of clover gave rise to the coldest air, and bare soil and dense wood gave rise to the warmest air. The air over the meadows and clover was about 6° F. colder than that over bare soil and woodland.

No sooner had this discovery been made than it was found that other scientists working in this country just over 100 years ago had discovered the same thing. They accounted for grass giving rise to relatively cold air and bare soil to relatively warm air on a radiation night as follows. The stems of the grass are poor conductors of heat, they tend to prevent the heat in the soil from passing up to replace the heat lost by radiation, and so the grass blades are greatly cooled and they cool the air in contact with them. On the other hand, heat radiated from bare soil is quickly replaced by heat from the deeper soil layers, so that the air above bare soil is not cooled so much as that above grass.

It was found that only grass exposed to the sky is able to cool by radiation. For example, grass growing under sweet cherry trees in leaf, planted 40 feet apart and standing about 40 feet high, cannot cool by radiation. It has been observed that on some nights there is no difference in the temperature of the air over grass and that over bare soil, a fact which, it seems, has not been previously reported, and the reason for which is being investigated.

An experiment showed that the difference between the air temperature at the bottom of Aylesford valley, altitude 40 feet, and Bluebell Hill two miles away, altitude 600 feet, is on the average 6° F. Therefore both altitude and vegetation can cause air temperature differences of about the same magnitude and on certain nights seem to be of equal importance.

Experiments made in a valley at Leckford, Hampshire, where the valley bottom fell 150 feet below the level of the hilltop in one mile, showed that the air over a sheltered meadow near the top of the valley was colder on many nights than the air over bare soil in the bottom of the valley. A katabatic wind flowed down this valley and acquired a temperature corresponding to the crop over which it flowed. Thus, in this particular place, the katabatic wind grew warmer as it descended, showing that air temperature differences due to vegetation can offset those caused by altitude.

Researches on Prevention of Frost Damage.

In the spring of 1936, sixty Harrington heaters were uniformly distributed on a square acre of standard and bush apples and plums in the middle of an 18 acre plantation of trees, planted 12 feet apart both ways, situated on almost level ground at this Research Station. Thermometers were placed at various heights above ground level both in the heated area and in a more or less similar place outside it. It was found that whether the heaters were alight or not a thermometer in the heated area recorded a higher temperature than that from a similar thermometer outside it. This was due to there being more exposed grass beside the control thermometer than in the heated area. These experiments have shown that, in order to make a just comparison between the air temperature in a heated and unheated plantation, the thermometers should be screened and placed at the same height above the ground in similar environments, especially with respect to exposed grass or weeds. The control thermometer must be on the leeward side of the heated area, and the thermometer inside the heated area must be centrally placed between four heaters, or at stated distances from them.

The work, which is far from complete, suggests that in orchards standing on the higher part of slopes and hilltops it is advantageous to expose the trees as much as possible to the hilltop wind on frosty nights in the hope of checking the accumulation of cold air. But caution should be exercised in removing hedges, windbreaks and woods which may offer valuable protection from high winds which come from the south-west in the autumn, or from cold dry winds coming from the north in the spring. Because lakes of exceptionally cold air form over grassland on some frosty nights, it is advisable to reduce as much as possible the amount of grass or weeds in and near fruit plantations during the blossoming season. Where grass is used to give colour to the apples it should be kept as short as possible in the spring. Orchard heating is likely to prove most successful on low-lying land where the air is almost dead calm on a frosty night, because otherwise air drifts carry out of the orchard the cloud of hot air from the heaters.

It is hoped, in the next three years, to extend and intensify the study of the effect of altitude and vegetation on air temperatures, the effect of the hilltop wind on the katabatic wind in different topographical situations, the factors influencing minimum

temperatures on hilltops, wind frosts, and the temperature changes in buds and blossoms during a spring frost. This research will be carried out, it is hoped, on a representative area of land several miles in length near this Research Station, and including a number of different soil types.

Summary.

Observations of air currents on hill-sides on radiation nights have shown that two winds exist, the hilltop wind and the katabatic wind. The effect of each on the other in certain localities is described.

Evidence is presented showing that when a katabatic wind moves down a slope its temperature does not necessarily decrease.

Experiments designed to demonstrate the size of air temperature differences caused by differences in (i) vegetation, (ii) altitude, and by a third unknown factor, are described.

Experiments are described indicating that certain conditions must be fulfilled in making a just comparison between the air temperature in an orchard-heated plantation and that in an unheated plantation.

TRIALS OF LOGANBERRIES, BLACKBERRIES AND HYBRID BERRIES

By A. BERYL BEAKBANE

THE vigour of Loganberry plants, their yield and fruit quality, have not been satisfactory in many growers' plantations for some years. There have been two main causes for this deterioration: (1) the large number of "rogue" Loganberries grown, and (2) the spread of the Cane Spot disease (*Elsinoë veneta*). The original Loganberry raised in 1881 was described as a vigorous, heavy cropping plant. True stock of this variety was first imported about thirty-five years ago, and plants propagated vegetatively from these early consignments are still available to-day. In addition, other true stock has been imported from time to time.

CLONAL SELECTION.

Unfortunately, however, seedlings from Loganberries, and even from other related varieties, have been sold under the name of Loganberry. Among 160 plants bought as loganberries from a single commercial source in 1929, 90 Phenomenal Berries, 4 Laxtonberries and 4 true Loganberries were identified in addition to 62 plants which were probably seedlings from either Loganberry or Phenomenal Berry. A few of the seedlings resembled one another very closely and may have been propagated by vegetative means since the seedling stage, but about fifty distinct forms were described. With the exception of one or two which were sterile, all the plants bore red fruits which did not separate from the " plug ", and they were all trailing in habit. In spite of this general similarity in habit and fruiting, however, the " rogue " plants differed from one another in size and colour of blossoms and number of petals, in size of fruit and its arrangement on the truss, in waxiness and colour of cane and in leaf shape. In quality also the fruits varied from berries which resembled those of the true Loganberry very closely to those which were so unevenly fertilized as to be mis-shapen and useless. Not one of them was better than the true Loganberry.

In order to determine whether this was an isolated case or whether many growers had had the same experience, a survey was made of a number of plantations in Kent and a few in other counties. While some of the plants surveyed were uniform in appearance and resembled the true Loganberry, many others contained mixtures quite as varied as that found among the plants bought by the Station in 1929.

After examining a large number of plants received as loganberry, one which appeared to be identical with the original Loganberry in vegetative and fruit characteristics was chosen and a clonal race raised from it, in order to give a supply of uniform material for field trials and for distribution to our members. A small quantity will be available for this purpose in 1939 and a greater amount in 1940.

CANE SPOT CONTROL BY MODIFIED TRAINING METHODS AND SPRAYING.

The second cause of the falling off in the yield of Loganberries is the weakening effect produced by the Cane Spot disease, which has become more widespread and intense in recent years. Work on this disease has been carried out at the Station since

1927. A trial of Loganberry and Phenomenal Berry was planted in 1935 to determine the effect of four methods of training and two spraying treatments on the incidence of Cane Spot. The disease can be distributed by spores splashed about by rain, and for this reason the position of the young cane in relation to the fruiting cane is of great importance. The worst place for the young cane from this point of view is directly under the fruiting cane, as it becomes infected during the summer when tied in this position. Hence all four methods of training employed were designed to obviate this. The young cane is either tied to one side of the plant as shown in Fig. 1, B and C, or trained first vertically and then above the fruiting cane as shown in Fig. 1, A and D. The fruiting cane is trained :—

A. as a fan (Fig. 1, A),

B. in one direction on double wirework (Fig. 1, B),

C. in one direction on single wirework (Fig. 1, C),

D. by weaving (Fig. 1, D).

The rows are always 7 ft. apart. In A and B the plants are at 6 ft., and in C and D at 12 ft. apart in the rows. In A the fruiting canes are tied to the wires singly in a fan shape and the tips of the canes removed. In B the plants are trained alternately first to one side, and then to the other, of double wirework in which the wires are at 1 ft. 6 in. apart in the horizontal plane. The fruiting canes are trained in one direction only and tied to the wires in three groups at different levels. When Loganberries are grown as close together as in methods A and B, the difficulty of training the fruiting cane without overcrowding is increased. This has been overcome in A by severe pruning and in B by using extra wires. In C the plants are trained in the same way as in B, but on single wirework. The fruiting canes in D are woven between three wires as shown in Fig. 1 D.

Every year the plants at 6 ft. have given a higher crop per acre than those at 12 ft. apart. For the first two years the amount was almost double, but in 1938 it was only 25 per cent. more. The highest yield for Loganberries that season was 11·5 lb. per plant (2·5 tons per acre), obtained with method D. With method C, the average yield was 10 lb. per plant (2·2 tons per acre) and, with each of A and B, 7 lb. per plant. As the plants trained by methods A and B are at 6 ft. apart in the rows the yield per acre was higher than with methods C and D, viz. 3 tons per acre. The more crowded plants at 6 ft. are subject to a greater risk of Cane Spot infection, however, and for them spraying is likely to be more necessary than for the more widely spaced plants as described below.

Similar differences in cropping were shown by the Phenomenal Berry, but the mean crop was 25 per cent. below that for Loganberry.

For the first three years, half the trial received a colloidal copper spray in June and half was unsprayed. The fungicide was incorporated in the derris spray for Raspberry Beetle control. There was no injury apart from moderate leaf bronzing, which occurred particularly on Phenomenal Berry. The young plants were healthy at the beginning of the trial and were not seriously affected by Cane Spot until 1937, when detailed records of its distribution were taken and a small but significant reduction in the amount of Cane Spot was observed on the sprayed plants.

In 1938 two applications of colloidal copper were given to the plots which had been unsprayed before, and the single spray treatment continued on the other plots. The general infection on plants in this trial proved to be much less severe than in 1937. Plants trained by methods C and D at 12 ft. apart were less severely affected than those

trained by methods A and B, at 6 ft. apart in the rows. There was no difference in the degree of infection between methods A and B or between C and D, but the crowding of the cane in the more closely planted plots appears to have had a considerable bearing on the incidence of the disease. Infection was lighter on plants sprayed in May and June than on those sprayed in June only, where the plants were at 6 ft. apart. Infection on the plants at 12 ft. apart was only very slight, as described above, and on these the addition of the earlier spray showed no improvement in control.

Varietal Trials.

The Phenomenal Berry was originally included in trials at this Station, because it was reputed to give a better canned product than the Loganberry. Comparable samples of the fruit of these two varieties have been sent to the Fruit and Vegetable Preservation Research Station, Campden, for canning tests over a period of five years. Very little difference has been found in the canning quality of the two varieties grown on this soil. Loganberry consistently gives a darker product than Phenomenal Berry, but this is not considered to be of great importance.

In the first year of cropping, Loganberry bore twice as much fruit as Phenomenal Berry, but in the second and third years only 25 per cent. more. The size of the Loganberries has been good, about 120 fruits to the pound, but Phenomenal Berry fruits have been even larger, averaging 85 to the pound, and they have been brighter and more attractive in appearance. Although Phenomenal Berry has these advantages of larger and brighter fruit over the Loganberry and it is also less susceptible to Cane Spot, it has one very serious drawback. It is highly susceptible to " dwarf " disease, a trouble causing fasciation of the cane leading to a severe dwarfing of the plant. Himalaya and one or two other varieties, e.g. Parsley-leaved Berry, may be infected by this disease, but they do not readily contract it unless they are near to Phenomenal Berry. The East Malling re-selected clonal Loganberry has not contracted the disease even when interplanted with Phenomenal Berry.

The recent blackberry trials include a comparison of plants propagated vegetatively from parents received as Himalaya and Black Diamond. The latter, although identical with Himalaya in vegetative characteristics, was reputed to give a better canned product. Comparable samples of fruit have been sent to Campden for four years. No difference has been found in the canning quality of these two sets of plants.

A promising variety that is not yet widely grown is the Youngberry, which bears large claret coloured fruit ripening a little later than Loganberry and before Himalaya. Youngberry fruits average about 100 to the pound as against about 170 to 200 for Himalaya. The berries are excellent for canning, and sell well in the fresh fruit market. The growth is very bushy and is consequently a little difficult to train, the plants are not very vigorous and need to be planted at 6 ft. apart in rows, 7 ft. apart on this soil. The crop per plant has averaged 5 lb. There is one serious danger with the Youngberry, however, as it is susceptible to " dwarf " disease in some parts of this country, although it has never developed the disease at East Malling. It is a cross between the very susceptible Phenomenal Berry and the Mayes Dewberry.

The Boysenberry resembles the Youngberry very closely, but the fruits and under-surfaces of the leaves are more hairy.

Bedford Giant blackberry, which promised well because it ripens a little earlier than Himalaya and has a good sized firm berry, has proved to be susceptible to a mosaic on the leaves at this Station. This trouble appears to have a somewhat dwarfing effect.

The fruit of John Innes blackberry is of excellent appearance and it may be a valuable garden variety. It is bushy in habit, and if it is used as a commercial plant

it must be treated very differently from Himalaya in pruning and training method and distance of planting. A broad-leaved form of the Parsley-leaved Berry has given moderate crops of late, firm berries of good flavour. An unnamed seedling raised by Mr. M. B. Crane has a better flavour than Himalaya, although it has not cropped so heavily.

Propagation Methods.

The re-selected clonal plants used in these trials have been raised from tip-layers. These are rooted in special nursery beds established for propagation purposes only. The parent plants are set out at 9 to 12 ft. apart each way and are cut back to 9 in. at the time of planting. They are de-blossomed every year to prevent seedlings occurring among the tip-plants. The soil is kept well cultivated until the first canes are long enough to be bent over and their tips buried in the soil. A hole is made about 6 in. deep, with one side vertical and one sloping slightly towards the plant. The tip is placed in the hole with the cane lying along the sloping side and soil is pressed firmly against it. Layering is begun early in July in normal seasons and continued as new shoots grow until the end of August.

More recently the Station has been successful in raising Loganberries, some blackberries, and several hybrid berries from leaf-bud cuttings taken in late summer and put in cold frames. These root readily, but need to be transplanted to nursery rows for a year before being put out in plantations (see next page).

Summary

(1) Two causes for the falling off in the yield of Loganberries in recent years are given, (i) the large number of " rogue " Loganberries grown and (ii) the spread of the Cane Spot disease (*Elsinoë veneta*).

(2) The distribution of " rogue " Loganberries and the re-selection of a clonal race of Loganberry are described.

(3) The incidence of Cane Spot on Loganberry and Phenomenal Berry is described. The possibility of controlling this disease by modified training methods and by spraying is discussed.

(4) The vigour and cropping of a number of blackberry and dewberry varieties is reported.

(5) Methods of vegetative propagation of blackberries and dewberries are given.

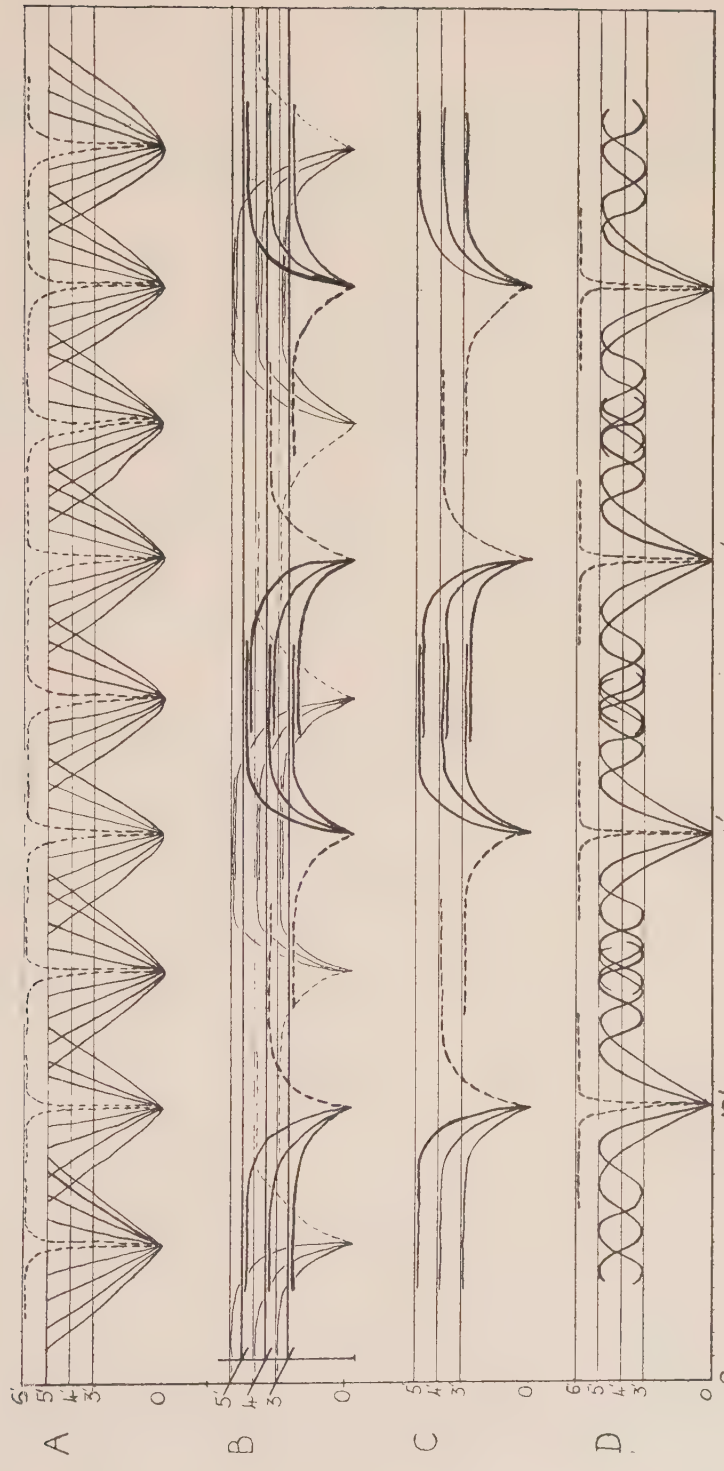

FIG. 1.

Training Methods for Loganberries.

(A) fan. (B) one-way on wirework. (C) one-way on single wirework. (D) weaving.

Fruiting canes ———— Young canes – – – – –

"LEAF-BUD" PROPAGATION OF LOGANBERRY, YOUNGBERRY AND BLACKBERRIES*

By R. J. GARNER and D. H. HAMMOND

Historical.

In October, 1931, Hagemann (3) published a summary of the literature on propagation by leaf cuttings ; he showed that, though many species of plants give rise to roots from detached leaves, comparatively few are able to initiate shoots as well as roots. It would seem that the propagation of plants by leaves alone is of limited application and, so far as is known, of no practical value in the propagation of the fruitgrower's material.

In May, 1932, Hunter (4) reported little success in propagating citrus by leaf cuttings but, at the same time, he found that leaf-bud cuttings (that is, cuttings each composed of a leaf with an axillary bud and a small portion of stem tissue attached) rooted within a fortnight and subsequently made strong plants. Hunter remarked that many more leaf-bud cuttings can be taken from one tree than cuttings of any other type, and that they occupy less space in the propagation pit or frame and are more easily handled and set in position.

In June, 1934, Stoutmayer, Maney and Pickett (5), and a few months later Tukey and Brase (7) in America, reported that leaf-bud cuttings of the black raspberry were from 80 to 100 per cent. successful, while first trials with blackberries were only partially successful. These American workers considered that the use of bottom heat in propagating frames was highly desirable. They also found that leaf-bud cuttings taken from the lateral shoots of one-year cuttings gave rise to flowers and no shoot growth occurred, whereas when cuttings were taken from the current season's shoots normal shoot growth resulted.

Tukey and Brase were of the opinion that the success of leaf-bud cuttings made the method a most useful one for the rapid multiplication of new varieties.

Trials at East Malling.

Following the results published by the workers mentioned, a few small trials were carried out at East Malling in 1935 with leaf-bud cuttings of the Cumberland Black raspberry. One plant was potted in the spring of 1935 and placed on the open bench in a propagation house. All the cuttings used (80) were taken from this one plant during May and June, and set, some in sand and some in unchopped sphagnum moss, both with bottom heat at 65 to 70° F. The number of cuttings which produced new plants varied from twelve to eighteen in the batches of twenty cuttings each. In using such small batches it is not safe to place much reliance on all results, but it may be of interest to record that the leaf-bud cuttings in sand produced shoots before roots whilst the cuttings in sphagnum moss produced roots before shoots.

In 1936, other species and varieties of *Rubus* were tested, but again only on a very small scale ; success was obtained with the Himalaya and the Parsley-leaved blackberries

* Reprinted from *The Gardeners' Chronicle*, 7th January, 1939, 9-11, by permission of the Editor, who lent us the blocks for the illustrations.

and with the Loganberry and Youngberry. Repeated attempts to strike leaf-bud cuttings of the Lloyd George red raspberry met with no success, though once again good plants were rapidly obtained from leaf-bud cuttings of black raspberry. In view of this difference between the behaviour of the red and the black raspberry it was considered possible that the success of leaf-bud cuttings is correlated with the property of tip-layering, seeing that the red raspberry Lloyd George does not multiply by tip-layers whereas the black raspberry is readily propagated by this method. A similar conclusion was arrived at in 1935 by Thomas (6).

Until 1937 all the leaf-bud cuttings taken at East Malling had been set in closed frames, with bottom heat, in a propagation house. When the cuttings were rooted it was necessary to box or pot them and gradually harden them off before they were in a fit condition for outside planting. All the cuttings had been obtained from stock plants in pots in the glasshouse as is the normal practice with soft-wood cuttings of many other species of plants. It was considered here that if the leaf-bud cutting method of propagation was to be useful to the fruitgrower the capital and labour costs involved in maintaining heated frames and glasshouses would have to be reduced drastically or dispensed with altogether. In 1937 and 1938, therefore, attempts were made to root certain species of *Rubus* in unheated frames out of doors, the cuttings being obtained from plants growing in the field. It was decided to employ subjects which were needed by the grower, and efforts were concentrated upon the hybrids Youngberry and Loganberry. The results are considered sufficiently successful for the method to be worthy of a detailed description.

Method.

Frames.

Unheated frames in the open air were constructed by screwing together 6 in. by $\frac{3}{4}$ in. sawn boards to form rectangular frames 6 ft. long by 4 ft. wide. These frames were placed upon freshly dug soil and one barrowload of humus material (very old decayed dung, peat-moss litter and coconut fibre refuse as available) with one barrowload of white sand was placed within each frame. This material was thoroughly incorporated with the top five or six inches of soil, trodden, and levelled off.

Source of cuttings.

All cuttings were taken during the growing season from re-selected, clonal, fruiting plants that had been trained on wires. One or two of the current season's shoots were removed from each plant according to the total number of shoots present and the vigour of the parent plant. The removal of a larger number of shoots might have seriously reduced the crop of fruit in the following year. Some cuttings were also taken from nursery plants which had already been tip-layered.

Preparation of cuttings.

All the leaves of the removed shoot were used except the small unexpanded ones at the upper end. On the average about twenty good leaves were obtained from each shoot. To prepare the cuttings the shoot is held by the lower end and a shallow cut (A) is made half an inch below the leaf as in the diagram. The knife is removed and a second cut (B) made, beginning half an inch above the leaf and passing under the bud (C) to meet the first cut (A). This second cut should not penetrate the pith but should pass parallel with the surface through the solid wood-cylinder which surrounds the pith. The cuttings are allowed to fall into a suitably placed receptacle, containing damp cloth, paper or moss, to prevent them from drying before they are set in the frame.

Setting the cuttings.

The cuttings should be planted as quickly as possible after preparation. A 6 ft. by 4 ft. frame will hold about four hundred cuttings of normal size. The cuttings should be placed about 2 in. apart in rows which are 5 in. apart. The base of the cutting is set so that the bud and small portion of stem attached to it is just below the surface of the medium and the upper surface of the leaf exposed to the light. When each frame is filled, a six by four pit light is placed upon it and covered with hessian, or other shading, according to the power of the sun. Wilting must be prevented, and attention to shading and occasional watering is of the utmost importance. Too much water, on the other hand, results in rotting of the cuttings and should be avoided.

After Care.

The frame-lights will generally remain closed for three or four weeks, by which time most of the cuttings will have formed sufficient roots for air to be safely admitted to the frame and the frame-light may be gradually raised until, at six to eight weeks after setting, the light is entirely removed. The rooted cuttings may be transplanted to the open field in the autumn, but at East Malling this operation has been postponed until the following spring when the plants have been set in nursery rows at 6 in. apart for a further season before they are transferred to permanent quarters.

Results.

The percentage of cuttings which have rooted in unheated frames has not, so far, compared favourably with the percentage rooted in heated frames within a propagation house where more factors are under control. In the trials with cuttings in unheated frames the proportion of rooted plants varied very much, and ranged from 20 to 80 per cent. This variation may be due to any or all of such factors as internal conditions of the cutting, the medium in which the cuttings are set and the amount of shading and watering. It appears likely that a normal return would be from 40 to 50 per cent.

A Comparison of the "Leaf-Bud" Method with Tip-layering.

The usual method of propagating loganberries and blackberries is by tip-layering either in the nursery or in the fruiting plantation. In the nursery forty rooted tips may be obtained from a single plant, whereas by the "leaf-bud" method one plant should yield up to 200 rooted plants. In the fruiting plantation a single Loganberry plant when tip-layered can be made to yield about six rooted tips without seriously diminishing the production of fruit the following year, whereas by the "leaf-bud" method two shoots from a fruiting plant each providing twenty "leaf-bud" cuttings may be expected to yield a minimum of twenty rooted plants, without any hindrance to cultivations. For the rapid multiplication of new varieties, and newly re-selected clones, the leaf-bud cutting has distinct advantages over other methods.

Some varieties of *Rubus* do not tip-root readily; at East Malling the Youngberry and Parsley-leaved Berry are of this nature. In such cases the leaf-bud cutting method is much preferred. The quality of the plants propagated from leaf-bud cuttings is excellent. In the spring of 1938, 451 plants of Youngberry and 95 of Parsley-leaved Berry were set out in a nursery row on unmanured ground. When measured in November of the same year these plants had reached an average height of 5 ft. and 3 ft. respectively. Thirteen rooted tips of Youngberry planted in the same row averaged $5\frac{1}{2}$ ft. in height over the same period. The time required to produce a plant from a leaf-bud cutting fit to set in a fruiting plantation is much the same as that taken to raise a tip-rooted plant. Both leaf-bud cuttings and tips are rooted during July, August and September, and in

October or March are fit to plant in local plantations or to be bedded in nursery rows in order to fit them for despatch to distant localities one year later. A yearling plant of Youngberry is shown in the accompanying figure along with a range of frames containing leaf-bud cuttings.

Suggestions for Commercial Application.

To ensure that good results are obtained with the least expenditure of labour, it is suggested that making the cuttings and setting them in the frames should be confined to the months July, August and September. If leaves are taken from the parent plants before July, only a comparatively small number from each shoot will be usable. On the other hand, if the work is delayed until after September cold weather may supervene and prevent the formation of roots, and the cuttings may die during the winter. It should be possible to obtain good results from mid-July to mid-September.

Where a limited number of lights are available the frames may be filled in July, and when protection is no longer required for these cuttings, in late August, the whole frame, with the lights, may be moved to another area and a second batch of cuttings planted in it. Light improvised shading will suggest itself for use by the grower who fears that the first batch are not quite ready for full exposure to the elements.

It is suggested that all rooted cuttings should remain in position until the spring, not only because some of the smaller ones may perish during the winter if transplanted during the autumn, but also because it has been found that even where the leaf-bud cutting has discarded its original leaf before the winter, without obvious signs of new growth, a vigorous root system may be developed, and a useful plant will then be produced from the bud in the spring.

Where growers are already using lights and frames for the raising of salads and other crops it will probably be found that the period July-September is also the most favourable time for sparing the lights from these projects.

It has been suggested by Beakbane (2) that in the tip-layering of plants in the fruiting plantation there is a risk of admixtures from seedlings which may be transplanted with the rooted tips. The risk of admixtures of this kind in leaf-bud cuttings is obviously not present.

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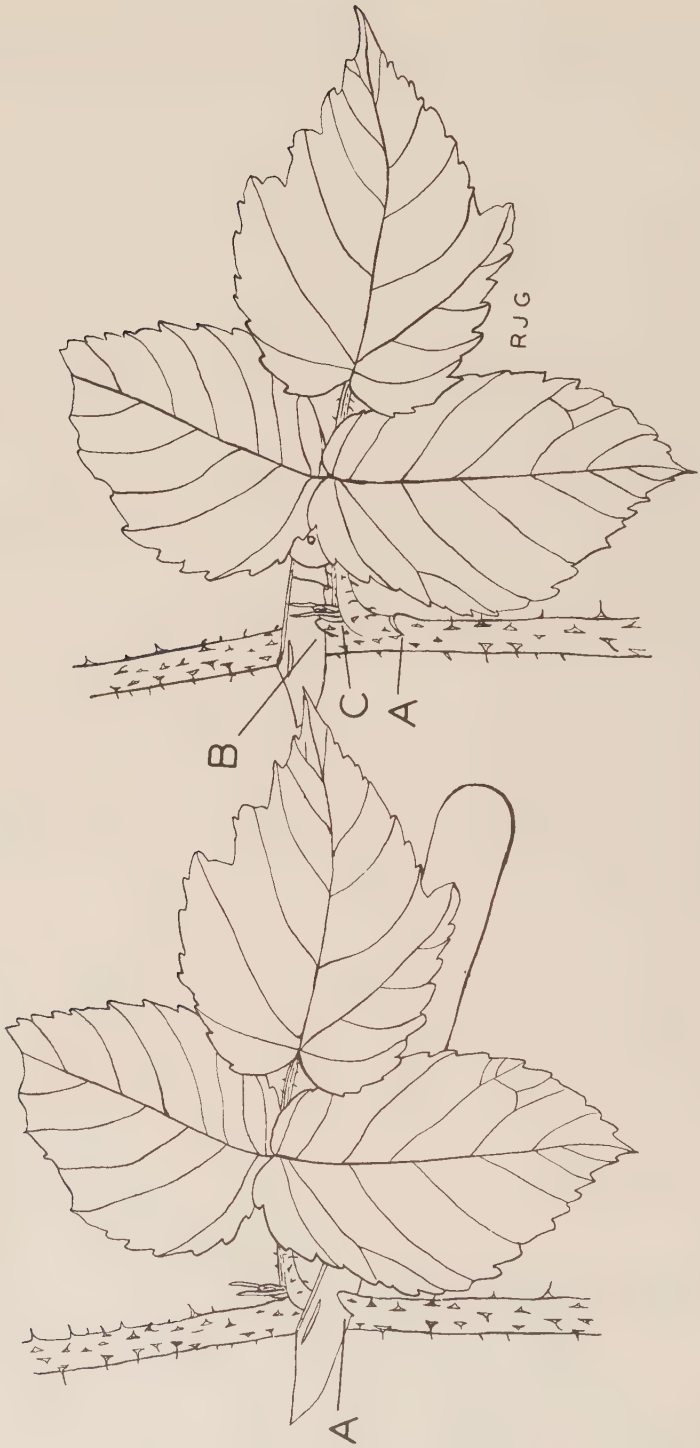


Fig. 1.
Preparation of a leaf-cutting of Loganberry.

FIG. 2.

Leaf Propagation of Loganberry and Youngberry.

Frames containing leaf-bud cuttings of Loganberry. The man is holding a yearling plant of Youngberry raised from a leaf-bud cutting. A Loganberry plant, six weeks old, is lying on the side rail of the frame light.

RESULTS OF RESEARCHES IN STRAWBERRY GROWING*

By W. S. ROGERS, MARY E. KING and A. M. MASSEE

STRAWBERRY growing today presents many problems, but we have found at East Malling that, given a good healthy stock, suitable soil and cultural conditions, and adequate control of diseases and pests, good results are obtainable. If any of these factors are neglected failure may result. This paper is intended to give a short summary of results which have been obtained by a team of workers tackling these problems from the cultural, disease and insect pest aspects simultaneously. For fuller details of the experiments leading to these conclusions, reference should be made to the publications listed at the end of this paper. In a few cases the full data are not yet published, but it is intended to present them shortly.

PROPAGATION AND CULTURAL PROBLEMS

(By W. S. ROGERS.)

"What shall we plant?" The most important answer, in our experience, is "clean healthy runners of a good stock". Though all the reasons for differences between stocks are not fully clear, we find that there are consistent differences even between selected clones† of a single variety. It is therefore desirable to choose a stock of a known good history. We have tested several clones of Royal Sovereign at East Malling, and the best so far available is the one distributed in quantity during the last three years as "East Malling clonal Royal Sovereign", raised from one plant selected in 1928.

RAISING DISEASE-FREE RUNNERS.

The most serious problem in many areas is the prevalence of the Yellow-edge and severe forms of the Crinkle virus (described fully on pages 228 and 229). Once infected, a plant never recovers but definitely deteriorates (see Fig. 4). A field containing a high percentage of virus-infected plants is therefore doomed from the start. The virus persists like a poison in the plants, and passes to all runners that are formed. Therefore the only way to free a stock from virus is to remove every plant that is affected. Unfortunately the virus symptoms may be "masked" (i.e. they are not visible) at certain times of the year, with the result that a succession of roguing operations is necessary. Under Malling conditions the best roguing times are usually May, July and September, but the exact times depend on weather conditions.

The most important roguing is the autumn one. This presents a special problem to runner raisers, because, with closely planted plants in ordinary rows, the runners will have formed a mat by September, and it will be impossible to separate healthy from infected runners. We therefore use and recommend the "Isolated block" method of planting runner beds. This consists of spacing the parent plants widely apart, 3 ft.

* Reprinted from *Scientific Horticulture*, 1939, **7**, 71-84, by permission of the Editor.

† A clone is a race of plants propagated vegetatively from one individual parent plant.

or even 4 ft. square (depending on the vigour obtainable) and laying the runners from each square of four plants together to form little isolated blocks, allowing cultivated alleys in both directions between. The first laying-in is in pairs, to allow horse cultivation to continue as long as possible, and finally two pairs form a single block (see Fig. 1). Thus if a late virus infection appears in certain blocks, all the plants from these blocks can be removed and destroyed without their runners having been in contact with those in other blocks. This is naturally an expensive method, because it entails much hand labour and some loss of plants by roguing, but by it we have produced in quantity Royal Sovereign plants, from which crops have exceeded 4 tons per acre. The yield of runners from Royal Sovereign parents at 3 ft. square has varied from 50,000 to 100,000 per acre according to weather conditions.

It must be realized that such runners cannot be considered as 100 per cent. virus-free ; they are only relatively virus-free. A small residue of virus may escape the most drastic roguing, and there is always the risk of re-infection. If aphides from virus-

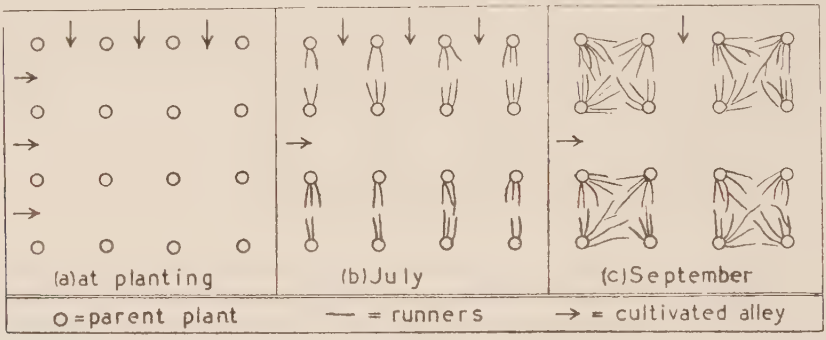


Fig. 1.

" Isolated Block " Runner Beds.

Plan of planting and runner laying, the parent plants being 3 ft. or 4 ft. square according to vigour.

infected plants feed on the healthy ones they infect them with the virus, for these plants are not immune from infection. The aphis is unfortunately very difficult to control (see page 231). Therefore the roguing and other precautions must be continued each year, and we ourselves have had to remove about 5 per cent. of the plants in our runner beds annually.

Measures to Prevent Re-infection.

Since aphides may bring the disease from infected to clean plants, *it is obviously most important not to plant clean plants (either for propagation or for fruiting) near old strawberry fields, which are likely to contain a high percentage of virus.* No distance can be quoted as absolutely safe, but the greater the isolation the better. While 100 yards is better than nothing, half a mile or more is desirable. The common practice of planting the young plants next to the old beds is quite fatal, for it makes rapid infection of the new plants extremely likely.

A further complication is provided by " carrier " varieties—certain varieties on which the virus symptoms are so completely masked that effective roguing is practically impossible (see page 228). These varieties include Huxley, Mme Lefebvre and Oberschlesien. Even healthy looking plants of these varieties are fairly sure to contain a high percentage of virus, therefore *such varieties must not be grown anywhere near*

susceptible varieties like Royal Sovereign and Paxton. Royal Sovereign planted near Huxley or Mme Lefebvre, for instance, is sure to deteriorate rapidly. The only sound policy at present, until we can ensure complete control of insect vectors, appears to be to plant " virus-free " susceptibles such as Royal Sovereign and Paxton in one part of a farm, and carriers such as Huxley and Mme Lefebvre in another. On small farms, either one group or the other should be chosen. If Royal Sovereign is used for pollination of Tardive de Leopold, which appears to come midway between the carriers and the susceptibles, the field should preferably be kept away from the main Royal Sovereign plantings. Alternatively Huxley may be used as the pollinator. (Fuller information on the virus status of different varieties is given on page 228.)

Choice of Runners.

Having decided on the planting policy, and taken all precautions to get healthy runners, the next question is whether any further runner selection is necessary. Which runners will give the best results ; big, small ; early, late ; first, second, last ; or of what class ? A careful study on this matter, in which the whole life history of each of some 2,500 individual strawberry plants was recorded (4) showed that all *healthy* runners of a good and productive stock have the same power to develop into vigorous and fruitful plants, once they have become established. The largest runners (which are normally those formed earliest) naturally make the best plants at the beginning of the first season, and if it is intended to let them crop as maidens, large runners give the best prospects ; but by the second season, which is normally the first commercial cropping season, the smaller runners have caught up the larger ones, and crop just as well (see Fig. 5). Under favourable conditions, it is possible to get runners weighing as little as 1 gm. to grow (see Fig. 3), this means about thirty plants to the ounce, but we do not recommend using such tiny plants, because they are much more liable to suffer and even die from adverse conditions following planting. A weight of about 4 gm. (i.e. about seven washed runners per ounce) seems the lowest commercial limit, and rather larger runners are safer if conditions are likely to be unfavourable. There is no need to limit the number of runners per parent plant in order to get successful results, however. In the experiments quoted, about 1,000 runners were obtained from six parent plants (by careful pegging down of the runners) and the average crop of all these plants in the first year of picking was over $3\frac{1}{2}$ tons per acre (4).

Planting.

The essentials for successful planting are that the ground should be warm enough and moist enough to ensure good root growth. Given these conditions, the earlier the planting the better the results. At Malling conditions are usually most suitable in September, October, February and March. Our autumn-planted plots generally do better than our spring-planted plots all through their life. It is important to plant with the crown at ground level. If planted too deep, the crown may be smothered and rot, especially in a wet winter. If too shallow, the plant may dry out, or be lifted by frost. Firm soil is essential for good planting, and rolling is often a useful finish to the preliminary cultivations.

If there is a risk that the runners may have Tarsonemid Mite on them, we should certainly give them the "warm water treatment" to eradicate this pest (see p. 231) and should be particularly careful to avoid unfavourable planting times, because of the check to growth caused by this treatment. In the absence of mite we should use a nicotine dip (see p. 232) to remove aphides.

Spacing.

We find that, within limits, the closer the plants the larger the crop per acre, and the wider the plants the larger the crop per plant. This applies to fruit and to runners. In a dry year, plants that are crowded suffer from drought, however, and in a wet picking season (such as 1937) Botrytis rot is much more severe on crowded plants. Therefore a compromise between very wide and very close spacing is desirable. For fruiting beds of Royal Sovereign, 12 inches to 18 inches apart in rows 30 inches to 36 inches apart seems best under Malling conditions.

De-blossoming.

We find that it usually pays to remove the blossoms in the season following planting as the small amount of fruit thus lost is more than repaid by the increased crop obtained in the next and later seasons, and the expense of strawing in the first season is also saved. In areas where July or August planting is possible, it may be worth while not to de-blossom, however, as the maiden-year crop may then be reasonably large. Also in areas where rapid re-infection with virus is inevitable it may be worth taking a maiden-year crop while the plants are still relatively vigorous. De-blossoming is most desirable for plants used for runner raising, as it not only increases the yield of early plants (3) but also avoids the risk of seedlings growing among the runners.

Manuring.

Feeding the strawberry plant is still not very thoroughly understood. In our experiments, farmyard manure up to about 40 tons per acre before planting improved plant vigour and cropping for two years, but showed little effect in the third year. Top dressings of meat and bone meal, about 600 lb. per acre each spring, plus 230 lb. sulphate of potash each winter, have also given good results. Similar amounts of nitrogen and phosphorus given as sulphate of ammonia (190 lb.), superphosphate (280 lb.) and steamed bone flour (100 lb.) were not quite so good ; and replacing the sulphate of ammonia with nitrate of soda (260 lb.) was still less satisfactory, though it was better than giving nothing at all (see also references 1, 2, 5).

Irrigation.

The strawberry plant seems rather susceptible to drought. We carried out two small irrigation trials in 1937 and 1938. In 1937 heavy rain followed the irrigation, and an increase in rots exactly offset the gain in crop on the irrigated plots. In 1938 water equal to 1 in. of rain, given just after the beginning of a very dry picking season, increased the first grade fruit by 70 per cent. and the total weight by 27 per cent. The water was given when the " soil moisture tension " (a measure of soil dryness given by the Malling soil moisture meters) reached 47 cm. of mercury, which is quite commonly attained in a dry summer. Irrigation therefore appears to be worth considering as a commercial proposition in dry periods in certain parts of Britain.

Burning.

Burning the straw litter in the rows, as soon as possible after fruiting, has proved successful in two small trials here. In both cases the crop in the following year was increased, although the size of plant was slightly decreased. Burning destroys the old leaves and with them many insects (see also page 94) and fungus spores. It also checks runner formation and weed growth. This treatment is evidently worth further investigation.

VIRUS DISEASES OF STRAWBERRIES

(By M. E. King)

One of the most important causes of the gradual deterioration of the commercial strawberry has been the incidence of virus diseases, which have spread through the strawberry stocks in most parts of the world. They were unfortunately not recognized as virus diseases until the degeneration that they cause had already become well established and widespread. The problem of dealing with the situation had then become much more difficult, but research work has shown that the diseases can be overcome if appropriate measures are taken. Once plants become infected with these diseases nothing can be done to save them, and thus methods of control aim at prevention instead of cure.

Yellow-edge.

Plakidas (12) described a virus degeneration disease of the Banner strawberry in California, and called the disease Xanthosis. Later Harris (7) described as Yellow-edge a similar disease on Royal Sovereign in England. Further work has shown that these two important diseases are probably identical. Diseased plants (see Fig. 4) are much reduced in vigour and cropping capacity, and usually do not die immediately but survive for several seasons, during which they act as a source of infection for other healthy plants. In this way the disease becomes spread throughout a large plantation.

Symptoms of Yellow-edge on Royal Sovereign (Fig. 7) are frequently masked during most of the year, but during late summer and autumn they usually show quite readily. The young leaves in the centre of the plant are the first to show signs of disease. No chlorophyll is present in the margins of the young leaflets and they therefore have a yellow edge. Moreover, marginal growth is restricted and cupping and curling of the leaflets result. The yellow edge is not hard and sharply defined, but merges gradually into the green tissue of the leaf, giving a soft appearance which is quite distinct from the hard yellow line sometimes seen on leaves during a dry summer. The irregular and diminished growth of the young leaflets results in a dwarfing of the leaf as a whole, and the leaflets become asymmetrical, and the petiole is abnormally short, stout, and lacking in red pigmentation. If the attack is severe and there are many such leaves, the whole plant presents a dwarfed and flattened appearance. Older leaves which developed before the plant began to show symptoms are quite normal in appearance.

The runners produced by diseased plants are also infected with virus, however healthy they may at first appear. The use of such runners for the establishment of new plantations is one of the means by which in the past the disease has been spread through strawberry areas. It is therefore most important to see that all infected plants and runners are removed from propagation beds so that new fruiting plantations are planted with healthy runners. Regular roguings of the propagation beds should take place during the summer and autumn and *all* infected and suspicious plants removed. Owing to the tendency for symptoms to be masked, especially in the case of plants only slightly infected, it is never possible to be quite certain that all infected plants have been removed and continuous inspections from year to year are necessary to maintain a healthy stock.

Actual contact between leaves and runners of diseased and healthy plants does not cause the spread of Yellow-edge from one plant to another. The rapid manner in which the disease spreads in a plantation is caused by an aphis *Capitophorus fragariae* Theob. If this insect feeds on a diseased plant it then carries the virus to healthy plants on which it may subsequently feed. Control of this insect is therefore another means by which

the spread of the disease may be checked (see p. 231 for further consideration of this aspect of the problem).

In the greenhouse it is more convenient to study the disease by the use of an artificial method of transmission. Harris (6) has devised a method of grafting strawberry stolons, by which the virus can be transmitted from one plant to another. At first the symptoms of Yellow-edge were studied on the variety Royal Sovereign but in later transmission experiments carried out by Harris (8), other varieties of cultivated strawberry and species of Fragaria were infected with the disease. There was a great variation in the intensity of symptom expression shown by the infected plants. Some plants such as *Fragaria vesca*, the wild strawberry, and the variety Little Scarlet showed great susceptibility and developed severe symptoms of Yellow-edge. *Fragaria chiloensis*, on the other hand, showed no sign of disease and no deterioration.

Of the other varieties of strawberries tested, some, such as Paxton, resembled Royal Sovereign in showing symptoms readily, and are called susceptible varieties; others, such as Mme Lefebvre and Oberschlesien, rarely showed symptoms although infected, and are hence known as carrier varieties. Apparently healthy plants of these different varieties of strawberry and different Fragaria species were also grafted to healthy Royal Sovereign, with the result that some of the carriers caused symptoms of Yellow-edge to appear on the Royal Sovereign, showing that they were already infected. Such symptomless carriers would therefore be a source of infection for susceptible varieties growing near them. In a mixed plantation only varieties of the same group (i.e. susceptible or carrier) should be grown together.

Just as the symptoms on Royal Sovereign tend to become masked at certain seasons and develop at other times, so the symptoms on other varieties vary. Even the so-called symptomless carriers show signs of disease at certain seasons and may deteriorate as much as Royal Sovereign. Other varieties such as Western Queen are intermediate between the two extremes. Hence the grouping of varieties into the two categories of susceptible and carrier is not a fixed rule, but a relative arrangement based on both greenhouse and field observations. Bearing these reservations in mind, the following grouping of present-day strawberries may give some guide as to the varieties which must not be grown together.

Susceptible.	*Intermediate.*	*Carrier.*
Fragaria vesca	Axbridge Early	*Fragaria chiloensis*
Little Scarlet	Madame Kooi	Madame Lefebvre
Deutsch Evern	Laxton	Oberschlesien
Royal Sovereign	Western Queen	Huxley
The Duke	Scarlet Queen	Bedford Champion
Sir Joseph Paxton	Early Cambridge	Super
Stirling Castle	(Boyes' Seedling)	
Pillnitz	Jucunda	
	Tardive de Leopold	

Susceptible varieties should not be grown with varieties of the other two groups. Moreover, virus-free stocks of a susceptible variety should not be grown with unrogued plants of another susceptible. Such virus-free stocks will only remain healthy so long as they are kept rogued and isolated from other sources of infection.

Crinkle.

The existence of another important virus disease was first realized by Zeller and Vaughan (13) and Zeller (14), who described the symptoms of Crinkle in U.S.A. They

noted both mild and severe forms of the disease under the same environmental conditions, and suggested that " there may be separable components of the virus, one producing more severe symptoms and another which might be termed a 'mild crinkle.' " Later, Crinkle on Royal Sovereign in the West of England was reported by Ogilvie, Swarbrick and Thompson (11), and they considered the disease to be the same as that found in America. Harris (9) studied the disease at East Malling and found it to be transmissible by stolon grafting.

On the young leaves of Crinkle-infected plants (see Fig. 8) small chlorotic spots develop, which do not grow, and as a consequence the leaves become distorted and crinkled. The severity of the distortion of the leaves depends upon the number and size of these chlorotic spots. In severe cases the spots increase considerably and develop a necrotic centre which is brownish purple in colour, and the leaves are badly distorted in consequence. The petiole does not seem to be much affected and the plant therefore remains domed, in contrast to the flattening of a plant which is severely infected with Yellow-edge.

The existence of Mild and Severe forms of the disease in the same plantation suggested that the two diseases were distinct as only a small number of the plants became severely affected. The exact difference between the two diseases is not yet fully understood, and the present position has been briefly discussed by Harris (10) in a recent note. There is no doubt that Mild Crinkle is widely distributed through existing strawberry stocks, and yet it does so little damage that it is frequently not noticed by the grower, who continues to obtain good crops of fruit from the plants. Mild Crinkle, therefore, need not be rogued from runner beds, but Severe Crinkle is dangerous and must be eliminated. There is, however, one difficulty in connection with roguing for Crinkle. The exact stage at which the disease becomes serious is very hard to define. An extreme case of Severe Crinkle and a normal case of Mild Crinkle are easy to recognize, but the intermediate symptoms might be those of the incipient phase of Severe Crinkle or the worst phase of Mild Crinkle. Hence the removal of all plants showing intermediate symptoms, though it would be the safest policy, might mean the wastage of good plants. In the present state of knowledge, it is best to leave such plants for a time and watch the development of symptoms, removing the plants as soon as definite signs of severe disease develop.

Fragaria vesca as Indicator.

The woodland strawberry *Fragaria vesca* proved to be extremely susceptible to both Yellow-edge and Crinkle when grafted to diseased plants. The symptoms of Yellow-edge on *F. vesca* are similar to those on Royal Sovereign, but Crinkle causes the formation of small blisters on the leaves accompanied by some chlorotic speckling and curling. Both Mild and Severe Crinkle cause the appearance of these characteristic symptoms, even when Mild Crinkle itself is scarcely visible on the diseased plant under examination. *F. vesca* has, therefore, been used as an indicator plant for determining the virus content of any unknown strain or variety. By grafting *F. vesca* to Yellow-edge infected Royal Sovereign, symptoms of both Yellow-edge and Crinkle were produced on *F. vesca*, thus showing that ordinary Yellow-edge diseased plants may also be infected with Crinkle, the latter being frequently invisible. Sometimes the two diseases are readily seen in the same plant, but usually one or other of the two viruses is dominant, more frequently this is Yellow-edge.

Conclusions.

Virus diseases of strawberries constitute a serious problem under present-day strawberry conditions. Once established in a strawberry area the diseases cause

considerable loss and are extremely difficult to eradicate. If, however, strawberry runner beds are maintained in isolated areas away from sources of infection and are regularly inspected and rogued, a supply of virus-free plants for new fruiting plantations can be obtained. These plants will, of course, not be resistant to further infection, but if they are isolated from other diseased plants they will remain healthy, and their increased crop will more than repay the trouble and expense involved in their production.

SOME IMPORTANT PESTS OF THE STRAWBERRY

(By A. M. Massee)

Strawberry Aphid.

The strawberry problem is further complicated by the fact, as demonstrated by Massee (15, 18) that under natural conditions the Yellow-edge and Crinkle virus diseases can be transferred from diseased to healthy plants by the strawberry aphis (*Capitophorus fragariae* Theob.). This aphid can be distinguished from other aphides which also occur on strawberry by its pale yellowish-white colour, the dark eyes, and the knobbed, hair-like processes on its body. At present only *Capitophorus fragariae* Theob. is known to be a vector of the strawberry virus diseases of this country, and experiments involving the use of other species of strawberry aphides, a white fly, a species of leaf hopper, the strawberry tarsonemid mite and the red spider mite have given negative results.

A study of the life-cycle of the strawberry aphid shows that two winged generations occur in one year. The first winged generation appears in the latter part of May or June, and the second takes place in the autumn, usually from the latter part of September until late November. Of these the May-June migration period is the more important, because the winged aphides fly readily during this time of the year, and seek fresh breeding grounds. Thus, when the aphides migrate from a badly virus-infected strawberry field to other strawberries in the district, an outbreak of disease invariably follows some weeks later. It has been demonstrated in several experiments that when a healthy strawberry plant is inoculated with virus-infested aphides, some virus symptoms become apparent on the plant after a period of six to seven weeks. As few as two to five aphides are sufficient to transmit the virus. These observations have been verified in the field.

This naturally suggests that as much isolation as possible should be sought when new strawberry fields are being planted. Unfortunately, it may prove to be very difficult, if not impossible, to obtain complete isolation—at least in many parts of Kent —and it will be very interesting to know if the migratory habits of the aphid differ in other parts of the country, where the climatic conditions vary from those of Kent. If so, it may be possible to find isolated areas where beds could be raised with little or no risk of aphides coming in from other districts.

It must be noted that the apterous (wingless) forms move about from plant to plant, thus once a strawberry field becomes infested, the aphides may move about and infest the whole plot, even in the absence of winged forms coming in from elsewhere (see Fig. 6).

There is no evidence to suggest that the winged forms which occur in the autumn fly from one field to another, in fact they have not been observed even to fly from one plant to another in the same field.

Of the alternative host plants, silverweed seems to be most favoured by the aphid, but since the aphid usually feeds on the strawberry plant all the year round, the alternative hosts would appear to be of little economic importance.

The problem of aphid control in the field is one of great concern. It should be noted that none of the measures suggested gives complete control. A nicotine and soft soap spray is undoubtedly the best means of affecting a reasonable control. The formula is as follows : nicotine (95-98 per cent.), 8 oz. ; soft soap, 6-8 lb. ; water, 100 gall. At least two applications are necessary. The first being applied in the latter part of May, just prior to the migration period ; and the second in June when the winged generation has finished flying about. It should be noted that the May-June migration period rarely lasts longer than one week. Observations will have to be made each season to ascertain the exact timing of each spray, which may vary considerably from year to year.

Derris sprays and dusts and also nicotine dusts have been tried extensively, but they do not effect sufficient control of the aphides to warrant their use commercially. Pyrethrum used in the form of an atomized spray has been tried for two seasons now on

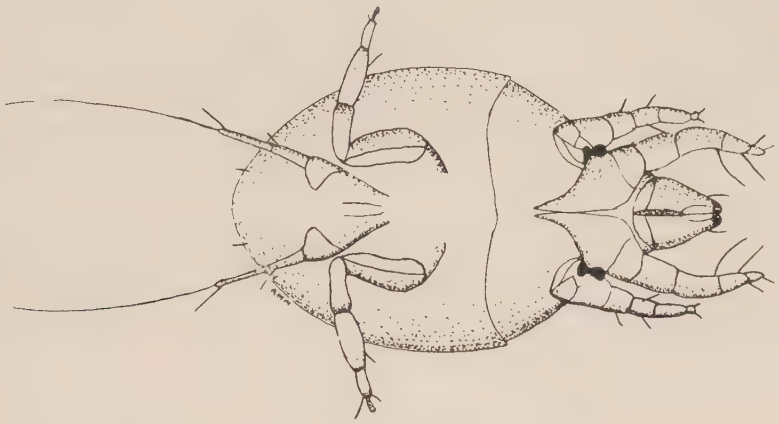


FIG. 2. *A. M. Massee del*

Strawberry Tarsonemid Mite
(*Tarsonemus pallidus* Banks) ×250.

a laboratory and field scale, but the results have been very unsatisfactory, even when the spray has been applied in a very extravagant manner.

Experiments with atomized nicotine have been much more hopeful, since it has been possible to destroy all the aphides on the plants in the field, and it now remains to be seen whether it can be used economically on a commercial scale. In the preliminary investigations the nicotine was applied by means of a portable air compressor plant, with an especially adapted nozzle for giving an atomized spray. The nicotine was used at concentrations varying from 1 to 10 per cent. with a water base. Vaporized nicotine is also being tested.

Meanwhile it is recommended that " virus-free " plants should be kept as far away from existing beds as possible, since the latter probably contain a high percentage of virus, and that " susceptible " varieties should be kept away from " carrier " varieties.

Strawberry Tarsonemid Mite.

The tarsonemid mite is frequently a very troublesome pest—especially in the South of England, in hot, dry seasons. The mites dwarf the plants in a very characteristic manner. The leaves become small, brittle, and turn yellowish in colour. In severe cases the foliage turns reddish and exhibits a " dried up " appearance. This

pest is serious for two reasons: (*a*) it severely weakens the plant, and (*b*) it makes the roguing of Yellow-edge and Crinkle impossible (17). Fortunately the mite cannot spread very rapidly, thus if plants are free of mites when planted out they usually remain clean. The only method of controlling the mite is the warm water treatment (16). There is as yet no way of destroying the mite in the field.

Warm Water Treatment.

This consists of immersing the young runner plants for twenty minutes in water at a temperature of 110° F. The water should be stirred at intervals, and a rack should be placed in the tank to prevent the plants from resting on the bottom. On removal the plants are plunged into cold water—to prevent heating—and then planted out as soon as possible. This treatment gives a complete control of mites and their eggs, and it also destroys such pests as aphides, red spider, leaf hoppers and numerous other insects. It must be noted that the treatment checks root formation for several weeks, hence it must be carried out only when weather conditions are suitable for good root formation. Best conditions may usually be found in September and October, and again in late February and March. The warm water treatment is necessary only when mite is present, and need not be used for runners obtained from warm-water treated plants.

Nicotine Dip for Runners.

In the absence of mite, it is a safeguard to dip the runners, just before planting, in a nicotine wash. The formula is as follows:—nicotine, 8 oz.; soft soap, 8 lb.; water, 100 gall. The whole plant, including the root, should be submerged, care being taken to wet the crowns in particular. This treatment ensures the removal of aphides, and has little or no detrimental effect upon subsequent growth.

Burning Strawberry Beds.

In order to reduce the insect population to a minimum in an established strawberry field, it is advisable to burn the straw litter directly the picking season has finished. It is realized that this operation can be done adequately only when weather conditions are favourable, but since it destroys the aphis it is to be strongly recommended. The burning operation proves to be of little use against the tarsonemid mite, since a large proportion of the mites live in the crown of the plant which is not affected by the treatment.

* * * *

This list of problems by no means exhausts the pitfalls that beset the strawberry grower. Our final recommendation is to keep a very close watch on the plants, so that anything appearing harmful or abnormal can be tackled at the outset. The following three points must be kept in mind throughout:—

(1) Virus-infected strawberry plants are, as far as we know, incurable.

(2) Isolation of healthy plants is necessary for prevention of infection.

(3) Making use of information on the life history of the virus-bearing aphides will help in obtaining better control of virus spread.

Summary.

Practical results of researches on strawberries at East Malling are given. The serious damage caused by aphis-borne virus diseases is described. Special reference is

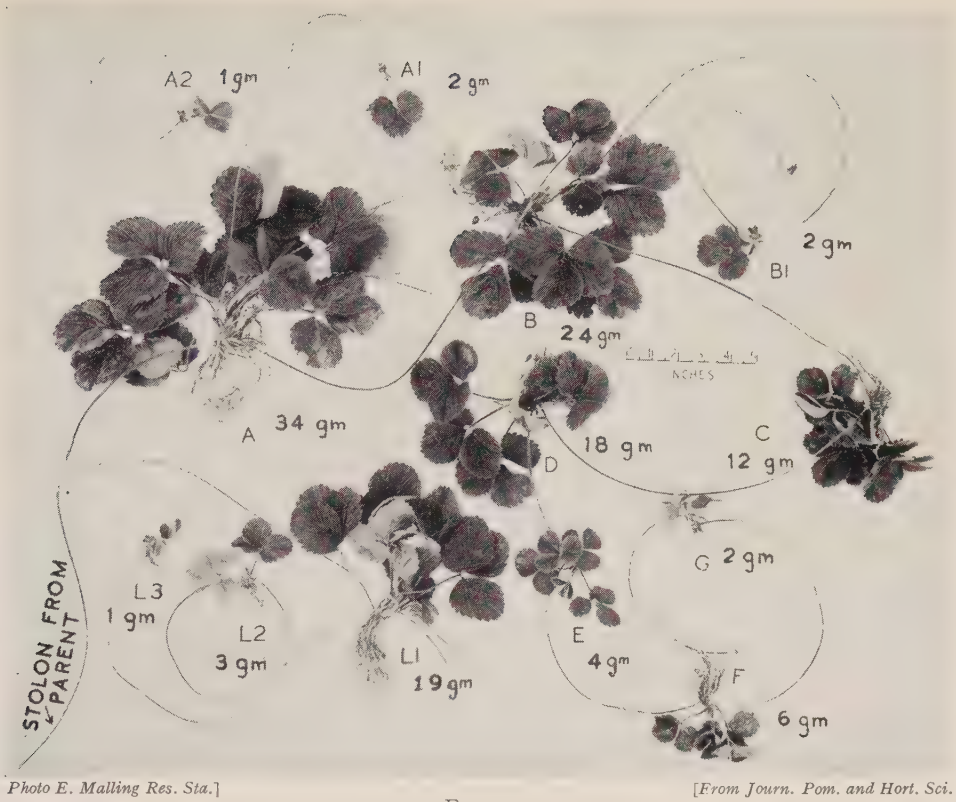


Photo E. Malling Res. Sta.] [*From Journ. Pom. and Hort. Sci.*

FIG. 3.

Strawberry Propagation.

Consecutive series of runners formed on one stolon, showing different classes of runner tested according to position on stolon, and relation between size of runner and fresh weight.

Photo E. Malling Res. Sta.] [*From Journ. Pom. and Hort. Sci.*

FIG. 4.

Royal Sovereign: Effect of Virus Infection.

Y. Yellow-edge affected. H. Healthy.

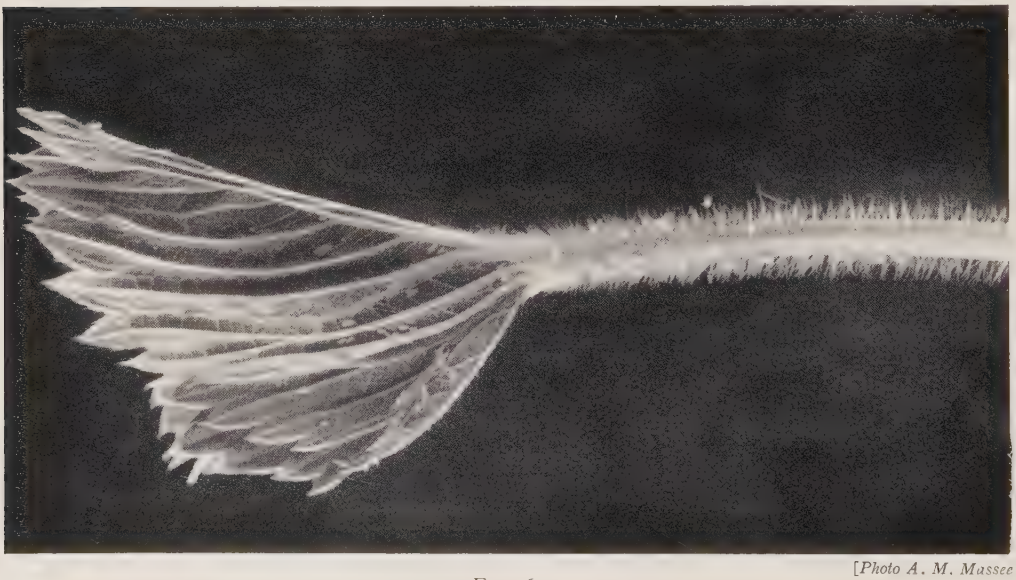
Two originally healthy plants produced from the same stolon in August, 1931. Y showed virus symptoms in September, 1932. Photograph taken May, 1933. (H and three other adjacent plants developed virus symptoms by October, 1933).

Photo E. Malling Res. Sta. [*From Journ. Pom. and Hort. Sci.*

FIG. 5.

Royal Sovereign : Vigour and uniformity of healthy Clones.

The plot contained all the progeny (numbering over 1,000) from six healthy plants. The runner-weights varied from 40 grams to 1 gram ; this photograph, taken in their third year, shows the uniformity and vigour which they attained. New selections are seen on the right.



[*Photo A. M. Massee*

FIG. 6.

Aphides Feeding on Young Strawberry Leaf.

[*Photo E. Malling Res. Sta.*

FIG. 7.
Royal Sovereign showing Yellow-edge Symptoms.

[*Photo E. Malling Res. Sta.*

FIG. 8.
Royal Sovereign showing Severe Crinkle Symptoms.

made to raising disease-free runners, measures to prevent virus infection, choice of runners, planting, spacing, de-blossoming and various other cultural measures. The Yellow-edge and Crinkle viruses are described, and the importance of keeping virus "carrier" varieties isolated from virus "susceptible" varieties is emphasized. Strawberry aphis and mite damage is described and control measures are suggested. Isolation of healthy plants is at present the best method of ensuring good results.

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BIOCHEMISTRY

PLANT INJECTION FOR THE DIAGNOSIS OF MINERAL DEFICIENCIES*

By B. F. G. LEVY

During the last eight years, Dr. W. A. Roach has been working out the technique for introducing solutions of nutrient substances directly into the conducting system of a plant, as distinct from supplying them externally via the soil in the usual way. In the past this practice has been known as plant " injection ", but this is not a good name, for no force is used in effecting the absorption of solution by the tree. The term has, however, been retained in order to avoid confusion and for the lack of a better one.

During that time Dr. Roach has been making investigations on the rôle played, in plant nutrition, by the " minor " elements and studying the possibility of correlating their presence or absence with differences in tree behaviour. It seemed that if he found that a particular element was generally associated with a particular pomological character (e.g. precocity of flowering), injection would be a suitable method for testing whether there was a causal connection. For he could inject that particular element and note whether the pomological character were reproduced. That, then, was the original reason for working on this method, but it soon became obvious that it would have wider uses, especially for the diagnosis of mineral deficiencies in the nutrition of the plant ; this is the main aspect that will be considered here.

Advantages of Injection.

The chief advantage of the injection method is that by its use one can ensure that the particular substance supplied will actually enter the plant system. Soil applications, on the other hand, may under various conditions fail to do so. Instances of such conditions are :—(*a*) in the absence of rain, the substance applied to the soil may never reach the plant's roots at all ; (*b*) with excessive rain the substance may be washed out of the soil before the plant has been able to absorb sufficient quantity ; (*c*) the element applied may become locked up in the soil either by becoming unavailable (as often happens with iron in high lime soils), or by combining with the soil particles ; (*d*) the element may react with the soil particles and replace another element which, being set free in the soil, may be absorbed by the plant roots, instead of the element originally applied.

A fertilizer experiment carried out at Rothamsted serves as an example of such a reaction. Comparisons were made between applications of similar salts of sodium and potassium. These showed that for several years the response on the two plots was similar, and the crops from both were shown to contain similar amounts of potassium. The reason for this was that the sodium that was applied was merely replacing the reserve of potassium that was already present in the soil, and it was this liberated potassium that was absorbed by the plant on the plots where sodium was applied.

* Reprinted from *Scientific Horticulture*, 1939, **7**, 50-9, by permission of the Editor. The figures in this article are reproduced by kind permission of the Imperial Bureau of Horticulture and Plantation Crops.

Thus it is seen that the application of a substance to the soil does not necessarily imply that that is what the plant receives. Moreover, even where a substance applied to the soil does eventually enter the plant system, it may have taken a considerable time before it reaches the roots (two or three years or more), thus bringing about a delay in its effect and possibly confusion in subsequent diagnosis. Such uncertainty is most undesirable in the diagnosis of mineral deficiencies or in any scientific experiments based upon it. With injection, however, the substance enters the plant rapidly and certainly, thus facilitating a speedy response and accurate diagnosis.

A further advantage is that by injecting various *parts* of a plant (leaf, shoot or branch) one can test the effect of several different substances at the same time and on the same tree. This makes possible a close comparison of the different effects and avoids the uncertainty due to the tree-to-tree variation, which is often serious, especially so with trees suffering from a nutritional deficiency. These, then, are the reasons why injection is advocated as a method of testing the effects of nutrient substances on plants. How it can be of use in diagnosing " deficiency " diseases in the field is best explained by giving an example.

Supposing one is confronted with the problem of improving a plantation in which the trees are in a poor state of health and in particular have chlorotic foliage. Assuming that the trouble is one of malnutrition, the first step, of course, would be to attempt to find out the cause. For this, some would rely on the symptoms shown by the tree which in this case might suggest iron deficiency. Symptoms, however, considered by themselves may be misleading ; for instance iron deficiency and potash deficiency may sometimes produce similar symptoms. For finding the cause of the trouble, others would rely on the results obtained from applying to trial plots different fertilizers (such as sulphate of potash or of iron). But they might have to wait some years before the trees gave definite responses to these treatments, which, moreover, as explained above, may not be reliable.

On the other hand, by using the injection method, one or two branches on a single tree could be treated with an iron salt and another one or two branches on the same tree with a potassium salt. This could be repeated on another tree, thus giving with half an hour's work, four replications of each treatment. If the trouble were a shortage of iron, the effect of the injection of iron sulphate should be a return of the green colour to the leaves, accompanied by increased shoot growth ; or if the potash salt brought about an improvement in the tree's health, then it could be assumed that that element was probably lacking in the tree. Definite responses to such treatment may be expected after a few weeks and, if all four of the replicates show a similar response, correct diagnosis is reasonably certain.

Then, of course, begins the usually more difficult task of curing the trouble by more orthodox cultural methods in the plantation. Injection itself is not usually worth while as a routine method of supplying nutrients on a field scale.

Methods of Injection.

Various methods of injection have been devised, each of which has its particular uses according to the object of the treatment and the type of growth available. The right choice of method is readily made with a little experience ; the chief point to remember is that the smaller the unit selected for injection the greater the number of treatments that can be conveniently tested on one plant, while the larger the unit selected the greater the number of physiological factors which can be affected. For instance, if a tree has five branches suitable for " branch " injection, at the most four different substances can be tested when using this method, whereas, if the interveinal

method were used, fifty or more suitable leaves could probably be found. On the other hand, with the interveinal method response is mainly limited to a change in colour, while with branch injections such factors as shoot growth, formation of new leaves, blossom formation, or growth of fruit can also be affected.

Most of these methods, being easy and rapid to manipulate, are quite suitable for field work. Moreover, owing to the quick responses that can be obtained, the certainty that the solutions have reached the tissues intended, and the number of substances that can be tested at once, the method should be very valuable for diagnosing mineral

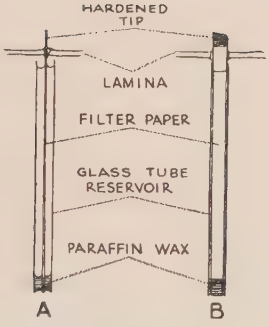

FIG. 1.
Apparatus for Interveinal Leaf Injection.

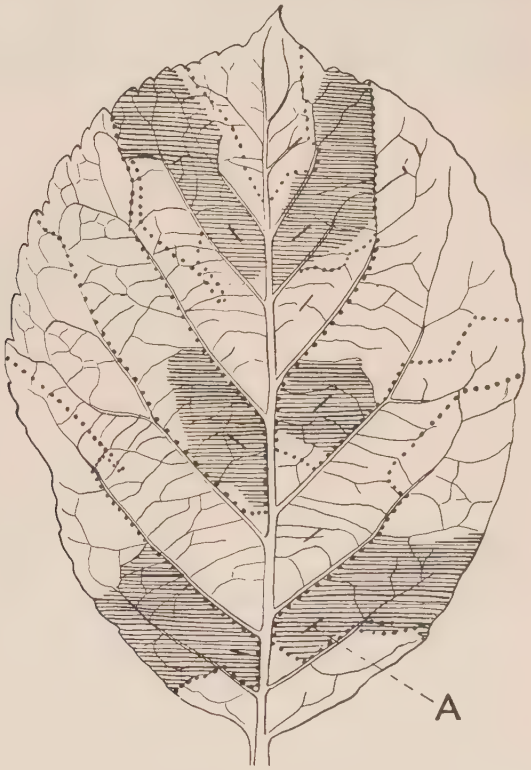

FIG. 2.
Result of Interveinal Injection of an Apple Leaf.

deficiencies in the field. It is not, however, suggested that injection should supplant other more orthodox methods of diagnosis and analysis, but that it may be used to supplement them.

Detailed descriptions and working instructions of the various methods of injection have recently been published by Dr. Roach.* The six main methods will, therefore, only be outlined here. Those wishing to use the methods themselves should refer to the above paper for full details, although methods Nos. 2 and 4 as described below can probably be carried out satisfactorily without further assistance.

* W. A. Roach (1938). "Plant Injection for Diagnostic and Curative Purposes." Imperial Bureau Hort. and Plant. Crops, Tech. Com., **10.**

1. *"Interveinal" Method.*—This is a method for injecting small portions of an individual leaf. A small glass capillary tube is used as a reservoir for holding the solution to be injected. Into this tube is inserted a wick of filter paper, the lower end of which is sealed in with a plug of paraffin wax and the upper end projects a few mm. above the tube, the tip being hardened (Fig. 1, A and B). The tube is filled with solution by means of a hypodermic syringe, the projecting end of the filter paper is then inserted into an incision in the leaf blade and the tube is allowed to hang. The water-conducting strands in the leaf tissues, which have been cut, come into contact with the wick and thus absorb the solution from the tube. The incision should be made in the area between two veins (A in Fig. 2), and this brings about permeation of the interveinal area which can be compared with the neighbouring untreated interveinal area. Young leaves are best used and then the response may first be detected in from three to seven days. This

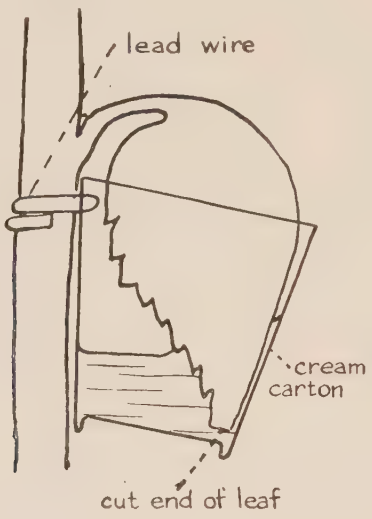

Fig. 3.
Leaf Tip Method.

method is most suitable for showing colour changes such as can be brought about by injections of iron, nitrogen, etc. The type of effect that can be obtained is shown by Fig. 2, in which the hatching represents the areas that were permeated by injections of dye solutions.

2. *"Leaf Tip" Method.*—This is a method for injecting a larger portion of a leaf. The tip of a leaf is cut off (about one-fifth of its length) at right angles to the midrib. The cut surface is then submerged in solution and the rest of the leaf will become permeated. The solution is contained in a reservoir, which can be made from a small cream carton or a glass specimen tube, and which can be conveniently suspended from the stem by lead wire (Fig. 3).

The more of the leaf that is cut off, the farther the solution will travel up the leaf: thus if one-tenth of the leaf's length is cut off, about half the leaf will be injected; while if one-fifth its length is cut, the whole of the leaf will be injected. If more than one-fifth is cut off, the solution will travel through the petiole into the stem and probably into the neighbouring leaves. Use of this fact is made in the next method (No. 3).

The " leaf tip " method has uses similar to the interveinal ; the latter shows much smaller differences in colour and gives a quicker response, but the " leaf tip " method is rather simpler to perform and needs no special apparatus. Responses by this method can usually be detected in about ten days after injection ; it can be used for any type of leaf and is the best method for injecting long leaves such as those of grasses, cereals, etc.

3. *" Leaf Stalk " Method.*—This is similar to the " leaf tip " method in principle, but here one cuts off the whole leaf blade, leaving only the leaf stalk to be immersed in the solution. This results in the solution being absorbed into the shoot stem and permeating the leaves above (and below) ; the actual distribution of the solution in these leaves varies with each type of plant according to the arrangement (phyllotaxis) of its leaves. In the apple, the first and second leaves above the injected leaf get about half

FIG. 4.
Leaf Stalk Method.
The liquid is held in a glass tube which is attached to the leaf stalk stump with rubber tubing. The permeated areas are represented black.

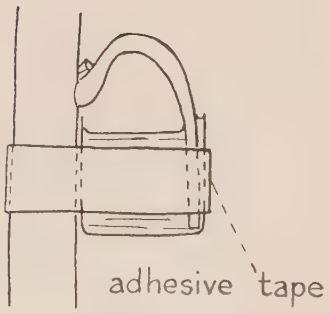

FIG. 5.
Alternative Leaf Stalk Method.

permeated longitudinally with solution (Fig. 4), the third fully permeated and the fourth not at all. This allows of three comparisons : two leaves in which one half can be compared with the other half and thirdly one completely injected leaf which can be compared with one uninjected. The leaves below are similarly permeated, but it is only the younger leaves above that are of interest for diagnostic purposes. In Fig. 4 the third leaf (above) is completely permeated, but, owing to its being as yet unfolded, it is not represented as such.

The apparatus used in this method consists of a tapered glass tube (such as can be made from a small test tube), the narrow end of which is connected to a short piece of bicycle valve tubing which, in turn, is slipped over the stump of the severed leaf stalk. The tube has to be filled with solution by means of a hypodermic syringe, the nozzle of which is pushed down the glass tube until it actually touches the stalk ; by this means

all air is expelled from the rubber tubing and an air lock is avoided. With apple leaves, the valve tubing usually fits the stalk conveniently, but in cases where the leaf stalk is not suitable, a method such as that shown in Fig. 5 can be used ; here the reservoir is a small glass pot or specimen tube.

The comparisons of the resulting colour changes are nearly as sharp as those obtained with the " interveinal " method, though the response is not quite so rapid. The question whether to use this or the " interveinal " method largely depends on the number of shoots that are available and the number of substances it is required to test. Since by this " leaf stalk " method only one substance can be tested on one shoot, the number of injection units is more limited.

4. *" Shoot and Branch Tip " Method.*—For the " shoot tip " method, about one-fifth from the top of a current year's shoot is cut off and the cut end immersed in solution (Fig. 6). This results in most of the remaining leaves on the shoot being injected.

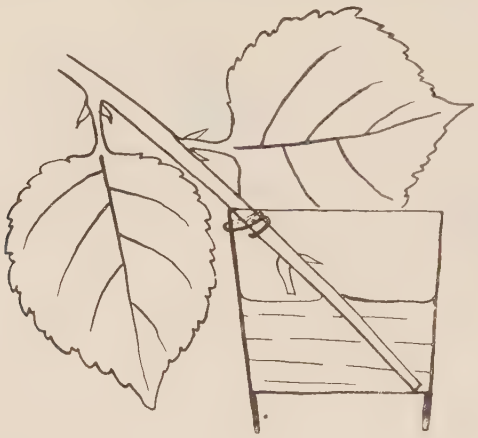

Fig. 6.
Shoot Tip Method.

As with the " leaf tip " method, the farther the cut is made from the end of the shoot the farther the solution travels. A cream carton fixed with lead wire is useful as a reservoir. The injected shoot should be compared, for a control, with a similar uninjected shoot, off which the same amount has been cut. For older branches the method is similar, except that one has to cut back into the older wood and the branch usually has to be weighed down before its cut end can be dipped into the receptacle.

Comparisons are not so exact with this method and it takes longer before an effect can be detected, but on the other hand growth and other responses can be observed in addition to colour changes.

5. *" Branch " Method.*—This method is carried out by injecting the solution into a hole drilled right through a branch at a point about two-thirds the way down its length (Fig. 7). (If the hole is made at this point and there are a sufficient number of spurs below the hole, no solution will pass round the crutch into the neighbouring branches.) The size of the hole (D) varies from $\frac{1}{4}$ in. to $\frac{1}{8}$ in. diameter according to the thickness of the branch. A milk carton (A) tied to the branch (B) forms a convenient reservoir for the solution and a piece of tubing (C) leading from a hole in its bottom can be connected to the hole in the branch by means of a pair of rubber pads (L, N) and glass tubes.

These rubber pads are bound into place by means of elastic strips made from bicycle tyre inner tubing, so as to keep the joins watertight (see Fig. 8). The success of this method depends largely on making as clean a hole as possible and special tools for the purpose are recommended.

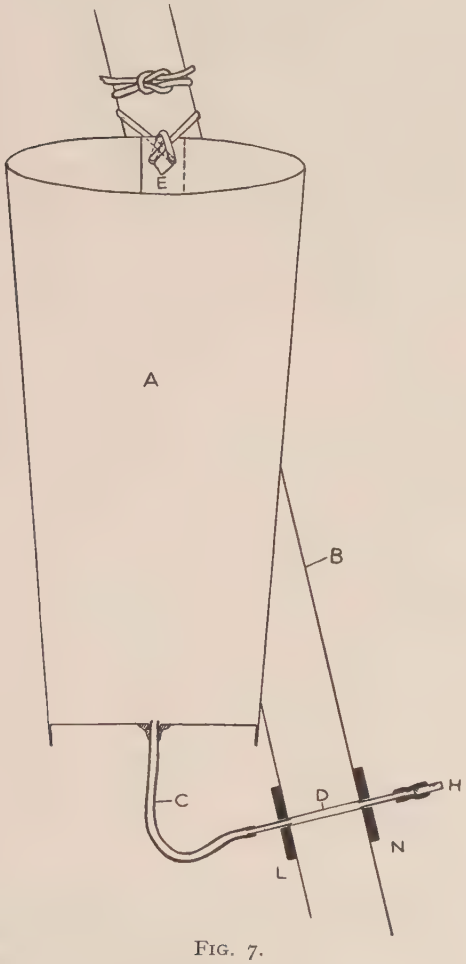

Fig. 7.
Branch Method.
The liquid is held in a milk carton A, attached to the branch B, and led through rubber tubing C, to the hole D which passes through a diameter of the branch.

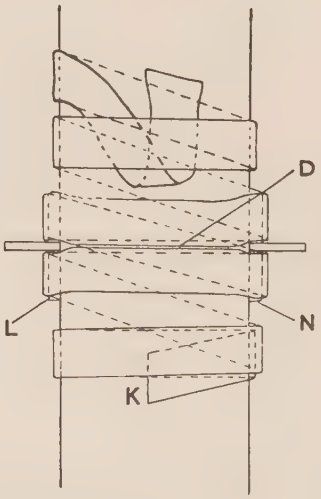

Fig. 8.
Branch Method.
To show binding of pads L, N.

By this type of injection the whole of the branch is permeated and, unlike the " tip " method (No. 4), the growing parts of the branch with the younger leaves are left intact. Thus the whole physiology of the branch can be affected and the response looked for on the leaves, the shoots, and the fruit. Branches of spur-pruned trees lend themselves readily to injection by this method, and since at least half a dozen similar branches are often available on such a type of tree, several different substances can be tested.

6. *"Whole Tree" Method.*—This method is not usually used for diagnostic purposes, except in cases where branch injections are impossible or where tree-to-tree variation happens to be less than branch variation, but it can be used for confirmation of results already obtained from branch or other injections. As a whole tree can be permeated, the method should be valuable for nutritional or physiological experimentation. Its use may sometimes be worth while as a method of curing a deficiency disease under circumstances in which no other means is practicable, or when the tree is in such a bad state of health that an immediate injection may save its life or crop, before a soil application would have had time to take effect.

It is carried out by boring two holes of $\frac{1}{4}$ in. diameter on opposite sides of the trunk of the tree ; the holes should reach to about the centre of the trunk but care must be taken that they do not actually meet. A wooden tub or bucket can be used as a reservoir, and is placed either in the crutch of the tree (if it is bush-shape) or on a box beside the

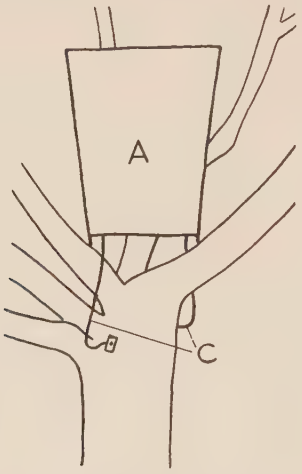

Fig. 9.
Whole Tree Method.
The liquid is held in a reservoir A and led through rubber tubing C to the hole in the tree trunk.

tree, arranged so that the reservoir is above the level of the holes. Tubes leading from the reservoir can then be connected to the holes in the tree (Fig. 9). The connection can be made in the case of the apple by means of a cork. This should be of the correct size to fit the hole in the tree, and should have a hole bored centrally down its length which can take the tube from the reservoir. The cork is then pushed into the hole in the tree making a water-tight join. The drawback of this method is that the cork, used thus, blocks up a few of the outer rings of wood in the trunk, and in some trees (such as the plum) these rings absorb the solution best. With apples this is not so, but with other trees a rather more complicated system may have to be used.

Preliminary Injections.

The exact application of these methods must be varied to some extent according to the type of plant being treated ; it is therefore recommended that preliminary injections should be made with dye solutions. The dye will indicate what parts of the plant have been permeated and the method can then be modified until permeation of

the part required is obtained. The best dyes to use are Patent Blue, Light Green or Acid Fuchsin (Red), at a concentration of 0·1 to 0·05 per cent.

Amount and Concentration of Solution.

The question of dosage is important but at the moment is largely a matter of experience. It must be realized that severe scorching of the leaves or death of the limb or tree can result from an overdose, so that it is best to make preliminary experiments on trees or plants of no great value. At least the injection should be stopped as soon as any signs of scorching appear on the leaves. The concentration at which a solution is used should also be studied. For substances containing " major " elements such as nitrogen, potassium or phosphorus (e.g. urea, potassium sulphate or sodium phosphate) a suitable strength of solution is 0·5 or 0·25 per cent., but for " minor " elements such as iron or boron a strength of 0·05 or 0·025 per cent. or less should be used. The lower concentration is the safer to use when the approximate dose is not known, but when some idea is obtained of the quantity to inject, the higher concentration may be used. This is often more convenient, as it entails the use of smaller quantities of water.

Summary.

Plant injection can be used for studying the rôle played by the " minor " elements and for diagnosis of mineral deficiencies in the field.

The advantages of this method compared with soil application are :—

(1) The certainty that the nutrients actually enter the plant.
(2) Different parts of a plant can be treated separately.

A brief example is given of the use of injection in diagnosing a " deficiency " disease in the field.

The six main methods of injection are outlined, with indications as to when each should be used.

Preliminary injections with dye solutions are recommended, and some guidance is given as to dosage.

MYCOLOGY AND BACTERIOLOGY

VERTICILLIUM WILT OF HOPS

A SUMMARY OF OBSERVATIONS DURING 1938

By W. G. KEYWORTH

INTRODUCTION.

This Wilt Disease of Hops was first noticed in 1924 in a garden at Penshurst. The first outbreak was examined by R. V. Harris (1) of East Malling, who since that time and until 1937 has been investigating the problem in collaboration with B. S. Furneaux (3) of Wye College.

During the years 1924-37 the disease was reported from a gradually increasing number of farms, and by 1937 its scope and intensity were such that many farmers had become seriously perturbed. Therefore at the suggestion of a number of Kent hop-growers, and with their financial support, an intensive study of the disease was started in July, 1938.

Up to, and including, the 1938 season the disease has been reported from twenty-eight farms in Kent and Sussex. Four of these are in Mid and East Kent, the rest in the Weald district. The disease has been found on one farm in Hereford. The hop varieties in which the disease has been found are Fuggle, Tolhurst and Tutsham as well as certain other Golding varieties and two Wye seedlings.

THE SYMPTOMS.

These are rather variable, but the principal ones are as follows :—

(1) The leaves turn yellow, often with streaky black markings, and then die.

(2) The bine sometimes becomes thickened (somewhat similar to a " pipey " bine).

(3) The bine pulls away fairly easily from the crown—but not very easily (i.e. it does not " grow off " as in Hop Canker).

(4) The wood inside a badly diseased bine is a light brown colour from the base to at least 18 in. up the bine. This symptom is the only constant one.

If bines are found showing some or all of the first three symptoms, and in addition the browning of the wood, Wilt disease should be suspected.

The disease can easily be confused with Canker or " Growing Off ". Canker is entirely different and at the present time is not so serious as *Verticillium* Wilt. In hop plants affected with Canker the bines pull away *very easily* from the crown and the wood inside the bine is not brown ; Canker can be controlled by hard dressing but no such treatment has been found to be effective against the Wilt disease.

The fate of hills affected with the *Verticillium* disease varies from farm to farm. Sometimes hills may show marked symptoms in one season but appear to be quite healthy in the next season, whereas on other farms the hills almost invariably die within either one or two years after developing symptoms.

The Causal Organism.

This was found by Harris (2) to be a fungus which he identified as *Verticillium albo-atrum* Reinke and Berth. This fungus lives in the soil and is thought to enter the hop plant through the roots. Inside the plant it grows in the vessels, causing the typical brown discoloration of the wood. In a badly diseased hill it can be found in the roots, the crown, and in the bines from the base upwards to the height of the top string, as well as in the leaves, laterals and leaf-stalks. Another species of *Verticillium* can also be a cause of Wilt. Thus in three hop gardens during the 1938 season hops were found attacked by *Verticillium Dahliae* Kleb. and in one of these gardens the affected plants were adjacent to raspberries also attacked by *V. Dahliae*. The symptoms produced on hops are the same as those caused by *V. albo-atrum*.

During the summer *Verticillium* fructifications were found on the bases of affected bines and on the dead leaves of such bines. In late September similar fructifications were found on dead hop leaves lying on the soil in a wilt patch. It is presumed that the fructifications are those of the wilt fungus, but this point has not been determined and it is not yet known whether the spores produced play any part in the dissemination of the wilt fungus.

The Incidence of Disease.

Farms on which the disease has appeared can be divided roughly into two classes :—

1. Those on which the disease varies in intensity from year to year (*Fluctuating Type*).

2. Those on which the hills almost invariably die within a year or two after they have shown symptoms and on which a young hill planted where a diseased hill has been grubbed usually shows symptoms and dies early, often in its first year (*Progressive Type*).

This division into two classes is not a definite one, and some of the attacks show variations between these two extremes. Eleven of the outbreaks investigated in 1938 were either too young to classify or did not fall definitely into either of the two extreme classes.

The reason for the variations between outbreaks is not known at present and is being made the subject of one branch of the investigation.

The First Type of Attack (Fluctuating).

There are nine farms showing this type of attack. Most of these outbreaks were investigated by Harris (2) who found that the wilting of hills on these farms is definitely greater when the summer months are wet (e.g. in 1936). He concluded that on such farms the fungus is present in hills in many parts of the garden, wilting occurring only in certain areas made wetter by underground springs. These springs fluctuate in volume according to the weather conditions. The last bad attack on such farms was in 1936, since when little wilt has been seen.

The Second Type of Attack (Progressive).

There are eight farms showing this type of attack. The disease on these farms is, of course, much more serious than on the others, because young hops die when planted in a wilt patch and so the land becomes useless for hop growing. All the outbreaks recorded have first appeared as patches of five to ten hills. In the course of one or two years these patches have rapidly increased in area and numerous hills with affected bines have

been seen in other parts of the garden, each apparently becoming the centre of a fresh wilt patch. In one 7-acre garden of this sort where twenty wilting hills in one patch were noticed in 1934, there are now about 2,000 infected hills (Fig. 2a). Fig. 1 shows a wilt patch in one such garden.

On all of the farms showing the second type of attack the disease has steadily increased from year to year and appears capable of continuing this increase unless it can be checked.

Spread of Disease.

In view of the fact that the disease is appearing in more and more farms and in some farms is becoming progressively more serious, it has been assumed that it is capable of spreading both within one farm and from one farm to another. Since the control measures which are to be suggested are mainly designed to check any possible spread, it is proposed first to give a short account of how spread of disease may occur.

I. *Spread within the hop-growing district.*

(*a*) *By Spores.* The spores which were mentioned as being present on the dead leaves and bine may spread the disease, but this point has not yet been investigated. Similarly, pieces of diseased leaves might blow from one farm to another.

(*b*) *By Planting Infected Sets.* It has not been shown definitely that sets can transmit the disease, but this must be considered as a possibility.

(*c*) *From Previous Crops.* On several farms Wilt has broken out in hops planted in ground previously cropped with potatoes. Since the hop wilt fungus is known to attack potatoes it is very possible that the hops have contracted the disease from the potatoes. Similarly, hops may perhaps contract wilt from raspberries infected with *Verticillium Dahliae.*

II. *Spread within an infected garden.*

(*a*) *In Cultivation.* Evidence has been obtained that the disease is probably spread through an infected garden by the cultivation processes. In Fig. 2 are illustrated two hop gardens on the same farm. 2a shows the extent of the disease in the 1938 season in a square-plant garden cultivated in both directions. In this garden the disease first appeared as a patch of twenty hills in 1934 and the diseased hills are now fairly evenly distributed all over the garden. 2b shows a Worcester-plant garden cultivated in one direction only. Disease broke out in 1936 in one patch and the diseased hills are now distributed almost entirely in one direction down the garden from the patch. Since it is known that the infected bines contain the mycelium of the parasite throughout the whole of their length and that the soil is infected round a diseased hill, it seems very likely that the cultivators spread disease by carrying such infected material about. If the disease does extend its range in this manner in the individual garden it is probable that it spreads from one garden to another in a similar way.

(*b*) *By the Use of Infected Bine as Manure.* On one farm green bine from an infected garden was put back onto a large part of that garden. In the next season the disease was very much worse and spread all over the area receiving the bine, whereas in a portion of the garden which was not manured with these bines no wilted hills were seen.

Control Measures.

At the present stage of the research on this problem no definite control measures can be recommended. It has been possible, however, to make some suggestions for the

next season. These should be regarded as experimental, and as the research progresses it may be necessary to modify them in the light of further knowledge. It is not possible to suggest any control measures which will be equally applicable to all farms, and recommendations must be based on individual circumstances.

A. *The Fluctuating Type of Attack.*

In the case of those farms where the disease is known to fluctuate annually the hills should not be grubbed unless badly wilted, but all wilting bines should be removed and burned. If the disease is known to be associated with a wet patch, drainage should be attempted.

B. *The Progressive Type of Attack.*

The following measures are suggested when the disease has been found to increase from year to year :—

(1) *Grubbing Infected Hills.* A close watch should be kept from early in the season for signs of wilting, and when a wilting hill is noticed it should *immediately* be grubbed and burned and the space not replanted with hops, or if only one or two bines are wilting these should be removed and burned. The position of the hill should be clearly marked—preferably with a painted stake—in order that the surrounding hills may be kept under close observation. Great care should be taken that the soil moved in grubbing is not scattered about the garden but is preferably replaced in the hole made. Where there is a large area of wilting hills, the whole patch should be grubbed and not replanted with hops.

(2) *Soil Disinfection.* This is recommended as an experimental measure after a wilted hill has been grubbed. Two doses, each of four gallons of 2 per cent. formalin,* are suggested, to be applied at least four weeks before replanting is attempted.

(3) *Disinfection of the Implements.* It is recommended that, if practicable, this should be attempted to check spread from one garden to another, or if this is not practicable an attempt should be made to ensure that the implements are free of bine and soil before proceeding from an infected garden to a clean one. An alternative is to keep the cultivation of diseased and clean gardens quite distinct, or to start cultivation in the gardens free from disease and to leave the worst till last, then cleaning the implements as thoroughly as possible before starting again in the clean gardens.

C. *New Outbreaks.*

All new outbreaks should be regarded as potential centres of infection and the most stringent precautions taken to eradicate the affected hills. The suggestions given in Section B should be followed as completely as possible.

D. *General Control Measures.*

The following apply to all outbreaks :—

1. *Bine Manure.* Bine from an infected garden should not be used as manure for hops. It is better to burn it.

2. *Planting of Hops after Other Crops.* Since *Verticillium albo-atrum* attacks potatoes and *V. Dahliae* attacks raspberries, it should be borne in mind that hops planted adjacent to or following these two crops may contract Wilt.

* 1 gallon commercial formalin in 50 gallons water.

3. *Diseased Sets.* Until definite information is obtained on whether the sets can carry disease, no sets should be taken from infected gardens.

Further Research.

This is to be concentrated on the following points :—

1. An investigation of the spread of disease both in infected gardens and from one farm to another.
2. Tests of soil disinfectants.
3. Trials of hop varieties for resistance.
4. A soil survey of affected gardens in collaboration with Mr. B. S. Furneaux of the South-Eastern Agricultural College.

Conclusion.

While this disease appears to be becoming a very serious problem in some districts, it is to be hoped that, with the co-operation of farmers in checking present attacks and reporting and suppressing new outbreaks, it will be possible to control it.

Only by close co-operation with growers can measures of control be elaborated, and any farmer who suspects the presence of the disease in his hops is urged to communicate with the Research Station.

Summary.

An account is given of the observations on *Verticillium* Wilt of hops during 1938. The symptoms of the disease and its incidence in various localities are described. Two very different types of attack have been noted—one fluctuating, the other steadily increasing in intensity from year to year. Provisional control measures are outlined, together with the lines of future research.

Acknowledgements.

The author wishes to express his gratitude to Mr. B. S. Furneaux, Soil Surveyor of the South-Eastern Agricultural College, Wye, for guidance in all matters related to soil ; without such help this side of the research would have been almost untouched.

References.

(1) Harris, R. V. " A Wilt Disease of Hops." E. Malling Res. Sta. Ann. Rep. for 1926, A7 (Supplement) (1927), 92-3.

(2) ———— " The Verticillium Wilt of Hops." E. Malling Res. Sta. Ann. Rep. for 1935, A19 (1936), 158-62.

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[*By courtesy of Fox Photos Ltd.*

FIG. 1.

A portion of a commercial hop-garden showing numerous wilted plants.

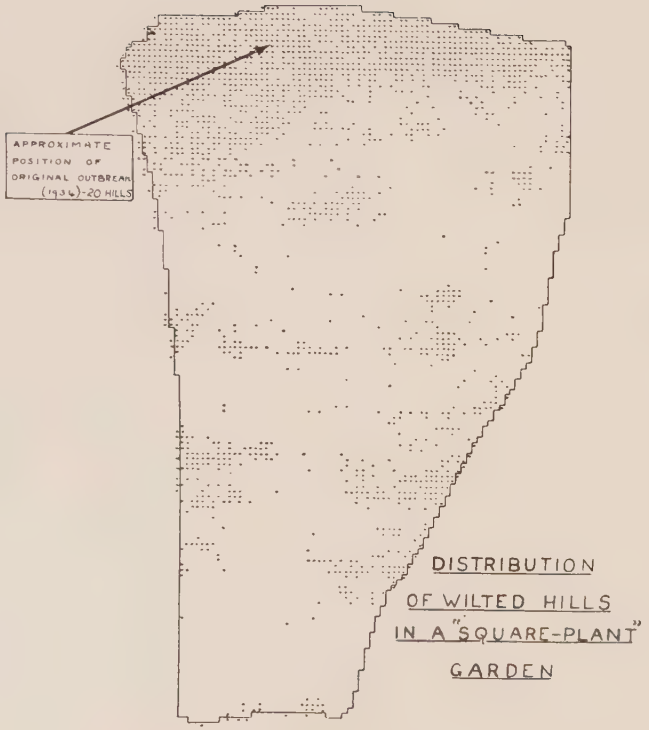
APPROXIMATE POSITION OF ORIGINAL OUTBREAK (1936)-20 HILLS
DISTRIBUTION OF WILTED HILLS IN A "SQUARE-PLANT" GARDEN

FIG. 2A.

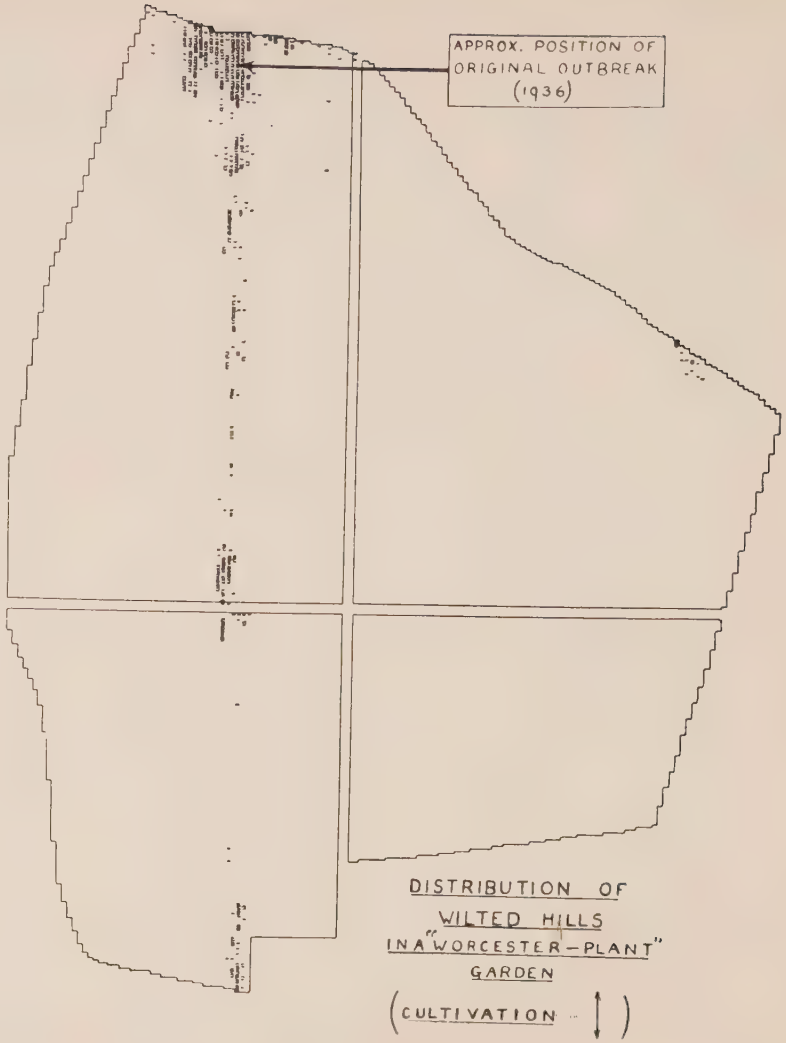
APPROX. POSITION OF ORIGINAL OUTBREAK (1936)
DISTRIBUTION OF WILTED HILLS IN A "WORCESTER-PLANT" GARDEN
(CULTIVATION ↕)

FIG. 2B.

ENTOMOLOGY

SUGGESTIONS FOR CONTROL OF STRAWBERRY APHIS

By R. M. GREENSLADE and A. M. MASSEE

The following recommendations for the control of the strawberry aphis are given to enable the grower to keep his plants reasonably free from this important pest, which is now essential in view of the importance of the aphis as a vector (carrier) of the Yellow-edge and Crinkle virus diseases.

It is not proposed to give here particulars of the various insecticides, dusts and atomized sprays, which have been used experimentally in an attempt to control the aphis, but simply to refer to the value of a nicotine spray (when used correctly), which has proved to be the most successful means, up to the present time, of reducing the aphid population.

Treatment of Runners before Planting.

The warm water treatment of runners, which has been dealt with fully elsewhere,* should be carried out as a matter of routine when climatic conditions allow, since it ensures the complete destruction of the aphis population and most other pests as well. Since the roots of the plants receive a check as the direct result of the treatment, it should be done only when soil conditions are suitable to allow of new root development. The best conditions may usually be found in August, September, October, March and April.

In some parts of the country the warm water treatment cannot be recommended owing to the risk of high mortality to the plants, and in such districts the practice of dipping the runners in an insecticide before planting is strongly recommended as an alternative.

The dipping process is a very simple one, and can be carried out quite quickly.

The plants should be submerged, just before planting, in a nicotine solution, particular care being taken to wet the crowns. The plants should remain in the solution for two or three minutes, and on removal should be allowed to dry off before planting.

If the runners are tied up in bundles, the strings should be cut before dipping, otherwise the plants in the centre may not get wetted thoroughly.

When the dipping is carried out carefully an almost complete control of the aphis will be obtained, and the plants will not be checked or injured in any way.

The formula recommended for this purpose is as follows :—

Nicotine (95-98%)	2 oz.
Soft soap	2 lb.
Water	25 gall.

* Massee, A. M. E. Malling Res. Sta., Misc. Publ. No. 14, 1936, 1-3.

Treatment of Runner Beds.

In order to keep runner beds reasonably free from aphides and to reduce the spread of virus diseases, it is essential to obtain some knowledge of the life cycle of the insect. It has been ascertained that the spring migration period is very important from the viewpoint of aphis control and the spread of virus. At this period the aphides develop wings and fly about from one strawberry field to another, and those insects which have been feeding on a virus plant previous to the migration period carry the virus and infect newly planted strawberry fields with the virus diseases.

The spring migration lasts for a period of about seven days. Unfortunately the winged migrants do not appear at the same time every year. Thus it is essential to examine the plants in detail and search for the winged forms in May or June. These are small dark insects with wings which occur amongst the familiar wingless forms (and are about the same size) on the under sides of the leaves. An illustration was published last year (E. Malling Res. Sta. Ann. Rep., page 209). In practice it would be best for the grower to get in touch with the Advisory Entomologist or Horticultural Superintendent for the county for detailed information.

Generally speaking it will be safe to make the first application of nicotine about the middle of May, before the winged forms mature and are ready to fly. A second application must be made directly the migration period has ended. This is essential because there is always a risk of aphides flying in from strawberries on a neighbouring farm and starting a new infestation—even if the plants have been sprayed thoroughly once already during the middle of May. The importance of the second application cannot be emphasized too strongly.

The formula is as follows :—

Nicotine (95-98%)	8 oz.
Soft soap	6 to 8 lb.
Water	100 gall.

A bent nozzle should be used for applying the spray, and a pressure of 250 lb. per sq. in. should be used.

The amount of spray used per acre will vary from 100 to 200 gallons, according to the size of the plants.

Treatment of Established Plants.

Under certain circumstances it may be advisable to spray established strawberry fields, though this measure is not generally recommended. If, for example, an established strawberry field is badly infested with aphides, and a large number of the plants are exhibiting virus symptoms, it will be necessary to spray twice (as recommended for young plants) to prevent the aphides migrating and carrying the virus to other young plants or runner beds growing in the neighbourhood.

Burning Straw Litter of Beds after Picking.

Apart from spraying, a further measure may be used in order to reduce the insect population to a minimum in the established strawberry field—namely, burning the straw litter of the beds directly picking has finished. It is realized that this operation can be done only when weather conditions are favourable ; if the burning is thorough, a high percentage of the aphis population will be destroyed.

It is frequently stated that by burning the straw litter the complete insect and mite population will be destroyed. Unfortunately this is not so, for the mites live mainly

in the crowns of the plants and are not affected, while many other sorts of insects make good their escape. Observations show that even a small percentage of the strawberry aphides survive—sufficient in fact to form the nucleus of a new infestation.

The practice of burning the beds should be regarded as a sanitary measure which is well worth while, as it materially helps to keep the insect population within bounds. This measure is specially recommended when young plants are growing near the fruiting beds.

Details of experimental work on the control of aphis will be found elsewhere in this report.

Summary.

Suggestions for the control of Strawberry Aphis are as follows :—

1. Warm water treatment or dipping of runners.

2. Spraying of runner beds with nicotine and soft soap just before and after the migration of the aphis.

3. Similar treatment of fruiting plantations in certain circumstances.

4. Burning of straw litter after picking the fruit.

INSECTICIDES AND FUNGICIDES

RECENT WORK ON FUNGICIDES AND INSECTICIDES AT EAST MALLING*

By M. H. MOORE, W. STEER and H. SHAW

INVESTIGATIONS WITH FUNGICIDES

(By M. H. Moore)

In recent years, experimental work on fungicides has been pursued along two main lines: (1) The improvement in the " performance " of well-known specifics such as Bordeaux mixture and lime-sulphur. (2) The testing of new spray materials. To facilitate the latter, a laboratory method has been evolved by which the fungicidal potentialities of likely spray chemicals can be determined as a preliminary to field trials of the more promising among them.

A further important line of work is the study of the conditions that predispose the tree towards susceptibility or resistance to disease and to spray injury. Of these, the scion variety and the rootstock form the " constitution " of the tree, while environmental factors include the soil and its management, manurial treatment and weather conditions.

In the past, Apple Scab, Pear Scab and Apple Mildew have formed the chief subjects for study, but recently the scope of the work has been widened to include Brown Rot in Morello cherries, Bacterial Canker in plums and cherries, Branch Blister in apples, Mildew in strawberries, and Cane Spot in loganberries. In the case of the last-named disease, the results given by spraying trials are set out on page 214 of Miss A. B. Beakbane's article. In all investigations, the possibility of combining insecticides and fungicides in one spray application has been regarded as of major importance.

Apple Scab.

Correct timing of the early sprays is of the greatest importance, two pre-blossom applications being considered essential for first-class control. If the earlier pre-blossom spray is thoroughly applied in advance of primary infection, even the necessarily weak post-blossom sprays will keep the trees clean. Bordeaux mixture and other copper preparations are not generally recommended for apples on account of spray injury; even mixtures too weak to be satisfactory fungicides have not proved safe. The inclusion of cotton-seed oil shows promise in reducing Bordeaux injury to foliage, but not, so far, to fruit. Lime-sulphur is recommended at present (2½ per cent. at green- and pink-bud, 1 per cent. at petal-fall, ¾ per cent. afterwards as necessary at fortnightly intervals), while colloidal sulphur (0·5 per cent.) can be successfully used as an alternative to lime-sulphur for post-petal-fall applications. Certain apple varieties are " sulphur shy ", especially Lane's Prince Albert, Rival, Beauty of Bath and Duchess Favourite, and here they cannot safely be sprayed post-blossom with lime-sulphur of adequate fungicidal strength. These varieties are also resistant to Scab, together with Edward VII,

* Reprinted from *Scientific Horticulture*, 1939, **7**, 85-95.

Charles Ross, Lord Derby, Gladstone, Early Victoria and Grenadier, which, in addition therefore, do not need post-blossom spraying for Scab. Stirling Castle is Scab-resistant and notoriously sulphur shy, and should not be treated with a sulphur spray or dust at any time during the growing season. The use of spreaders has not increased the protective control of Scab, while ferrous sulphate has failed to maintain early promise of obviating injury from lime-sulphur with lead arsenate. Of the new potential fungicides, a zinc-lime mixture and an organic sulphur preparation, tetramethylthiuram disulphide, have each shown initial promise in the field and further experiments with them will be made.

Spraying in bloom has received attention recently, and a search is being continued for a fungicide that can be applied to trees at some stage in the blossom period without causing serious loss of crop. Such a fungicide would be of great value in a season such as the present one (1938), when Scab made rapid headway during a cool, wet blossom period.

There is only limited information so far on the relation between manurial treatment and susceptibility to Scab and spray injury, but a manurial trial designed primarily to supply such data has been undertaken, and, it is hoped, will yield results in the course of the next few years. There is evidence that high nitrogen conditions favour the incidence of Scab and that suitable applications of potash tend to counteract this. It is sufficiently clear, however, that the general issue is not nearly as simple as that, and further work is necessary to clarify the complex of interacting factors, amongst which weather conditions play a very important part. It is fairly certain that grassing-down reduces the tendency to Scab, and that certain rootstocks are associated with less susceptibility to Scab than others.

In most of these investigations opportunity is taken to study the control of Apple Mildew. The spraying programme recommended for Apple Scab is the most effective also against Mildew.

Pear Scab.

This is inherently more difficult to control than is Apple Scab, especially with an all-lime-sulphur programme, mainly because 1 per cent. post-blossom, the upper limit of safety for many varieties in warm weather, seems to be inadequate to cope effectively with Pear Scab during weather conditions favourable for that fungus. Bordeaux mixture at 8-12-100 is too harmful, for it causes serious fruit-cracking, especially when applied pre-blossom. At present it is recommended to apply lime-sulphur (2½ per cent.) shortly after bud-burst and at white-bud, and Bordeaux mixture (4-6-100) with cotton-seed oil (3 quarts per 100 gal.=0·75 per cent.) at petal-fall and again two or three weeks afterwards.

Brown Rot in Morello Cherries.

Experiments conducted over several years have shown that first in importance as a measure of control is the cutting-out of infected twigs. This is best done in spring when they can most readily be seen, and, coupled with one application of tar-oil (10 per cent.) late in January and one application of Bordeaux mixture (6-9-100) just pre-blossom, excellent control should be obtained. In trials here, the inclusion of a spreader did not increase the control given by a pre-blossom application of Bordeaux mixture or lime-sulphur : the latter fungicide at 2 per cent. gave good control but caused some bud damage, while Bordeaux proved generally safe. On standard plums and sweet cherries, where the cutting-out of infected parts is scarcely practicable, reliance should be placed

on spraying where infection is severe enough to warrant it. Infected plums and sweet cherries are a menace to neighbouring Morello cherries, particularly when the weather at blossom time is wet and windy. Brown Rot can very rapidly become epidemic and can cause very serious losses under such conditions. Recently the respective merits of certain components of tar-oil emulsion against Brown Rot have been studied in a field trial, but results to date are not conclusive.

Bacterial " Shot-hole " and Canker in Stone Fruits.

The incidence of cankers on the susceptible Bigarreau de Schrecken cherry has for several years been considerably reduced by spraying with Bordeaux mixture in both autumn and spring. Two autumn applications (each at 10-15-100), one a few weeks before leaf-fall and the other at leaf-fall, together gave no better result than the earlier one alone. Similarly, two spring applications (each at 6-9-100), one just pre- and the other just post-blossom, together gave no better result than the pre-blossom one alone.* A combination of one autumn and one spring spray (in each case the earlier one), however, gave twice as good control as either separately. A spraying trial of Bordeaux mixture on young, double-worked Victoria plums has so far yielded few results and is being continued. Bordeaux mixture at 6-9-100 has proved unsafe on the foliage of both Bigarreau de Schrecken cherry and Victoria plum when used to control bacterial " shot-hole " on the leaves. Some promise has been shown by Bordeaux (4-6-100) with cotton-seed oil (0·75 per cent.) which is safer, but more experience of this spray is desirable.

Apple Branch-blister Disease.

This is most commonly found on Cox's Orange Pippin on No. II rootstock, especially on light, arid soils. It was frequently reported from Essex during the dry seasons of 1933, 1934 and 1935, when growers were trying to establish young plantations of Cox's on this rootstock. Believed by certain investigators to be due to attack by the fungus *Coniothecium chomatosporum*, the disease has been shown by recent research work to be physiological in origin. It is associated with both lack of moisture and of available potash (other factors also may be involved), and further experiments are under way to test the influence of these factors on young Cox's trees in pots. Irrigation, where practicable, in dry soils and the addition of bulky, moisture-retaining organic matter such as humus or shoddy, are recommended as control measures. Potash should be given where this is likely to be deficient, although its availability is probably governed by the moisture content of the soil.

The fruit-russeting sometimes associated with this disease is likely to be merely a further symptom of the deficiencies mentioned above, and may be a direct effect, or an indirect effect through lack of sufficient shade from hot sunshine, owing to the sparse foliage of affected trees.

Fusarium Bud-rot of Apple.

The fungus causing this disease, commonly found on the apple variety Grenadier, has been isolated and its parasitism proved by inoculation. The investigation was begun because of the confusion existing between damage caused by this fungus and that by certain sprays, notably winter petroleum-oil emulsion. A means of control is not yet known.

* Pending further knowledge, it may, nevertheless, be wise in practice to make two applications at each period on young trees, as an insurance against the vagaries of the season.

Strawberry Mildew.

Lime-sulphur (2 per cent.) has given more lasting control than sulphur dust, but it may cause leaf-burn in hot weather, when 1 per cent. would be preferable. Sulphur dust has given good control but needs frequent application. It is advisable to apply the fungicide in advance of infection, starting, for fruiting plants, towards the end of April or early in May, and to maintain a regular routine. Runner beds should be regularly sprayed or dusted during the later summer months.

INVESTIGATIONS WITH INSECTICIDES

(By W. Steer)

Four pests of fruit crops that have received a good deal of attention at East Malling in recent years are :—Raspberry Beetle (*Byturus tomentosus*), Apple Sawfly (*Hoplocampa testudinea*), Apple Blossom Weevil (*Anthonomus pomorum*) and Codling Moth (*Cydia pomonella*).

Raspberry Beetle.

Our research (8, 9, 10, 11, 12) began in 1927 with a study of the habits of the pest. We soon realized that the larva in its early stage is mainly an external feeder and seldom penetrates deeply into the berry till the drupels soften. It seemed likely, therefore, that an application of a toxic material at as late a date as possible would be effective. Our first, preliminary, experiments in 1928 encouraged us to explore the possibilities of derris which, unlike lead arsenate, gives rise to no dangerous deposit on the fruit. At that time this insecticide was almost unknown as such, although a few proprietary forms had been sold under trade names for many years.

Most of our trials have been made with a wet spray intended to kill the larvae before they can damage the fruit. We first used a dry form of derris in 1931, when we made up a dust and tested it against the larvae. In the following and subsequent years derris dusts gained great popularity and came to be used more and more against the adult stage. They are now probably more widely used than wet sprays for controlling Raspberry Beetle.

The present position is that growers have the choice of two methods of control : (*a*) The destruction of the adult beetles by the use of derris dust just before blossoming and again during blossoming. (*b*) The destruction of the larvae by a post-blossom application of a derris and soap wash, normally late in June, at the time the earliest Lloyd George raspberries are reddening.

Apple Sawfly.

Our main spraying trials (1) were carried out in 1933. At that time it was generally believed, as a result of Petherbridge's work (7), that nicotine should be applied at the time the larvae hatch. Some workers (3, 4, 5, 6) considered that the eggs also were vulnerable, but only when about to hatch. The critical stage for spraying must, it was thought, be of short duration since nicotine spraying was not always found to give good results. Inconsistent results had also been obtained in trials of lead arsenate.

We set ourselves the task, therefore, of finding out the optimum time for spraying and the comparative effectiveness of nicotine, derris and lead arsenate. We concluded from the results of our trials that nicotine is toxic to the egg in any stage of development. We obtained an 80 per cent. control by spraying at any time whilst the pest was in its egg stage, but only a 50 per cent. control if spraying was delayed till hatching began.

Derris, whether applied before or at the beginning of hatching, gave about a 50 per cent. kill, whilst lead arsenate had very little effect. In trials of wetters (13) we were unable to show that the addition of a wetter improved the control of Sawfly given by a petal-fall application of lime-sulphur and nicotine.

As a result of our trials, we recommend the addition of nicotine (8 oz. per 100 gallons) to the petal-fall Scab spray and urge, both for Scab control and Sawfly control, that this spray be put on early, namely, before all the petals are off. Spraying is less effective once the larvae begin to hatch. Moreover, the trees should be well drenched to make sure of filling the eye of the fruitlet with spray fluid.

Apple Blossom Weevil.

We cannot claim that our efforts to control this pest have been outstandingly successful (2, 13). We found that the weevils were very susceptible to the action of derris and so we conceived the idea of coating the trees with a derris dust at the time the weevils are laying their eggs.

We were able in this way to reduce weevil damage by about 50 per cent., but we found that the weather conditions at the time when the dust should go on are usually unfavourable. In our trials the prevalence of windy weather gave us few opportunities of applying the dust and, as often as not, the dust was washed off again by rain almost as soon as it had been put on.

Codling Moth.

This pest has received a good deal of attention in recent years. We find here that there is really only one generation a year to be dealt with—a partial second generation occurs in some seasons but it is comparatively unimportant. We have studied the life history of this insect under our local conditions (14, 15) and consider that an application of lead arsenate in late June gives an adequate measure of control. At this time the earliest eggs hatch and the tiny larvae begin to attack the fruit. There is, therefore, no need to spray earlier. On the other hand the spray deposit is persistent enough to kill most of the larvae that hatch out in July and August.

Testing of Insecticides.

This now forms an important part of our work. Potential new spray materials are from time to time examined and the more promising of them are ultimately tried out in the field against well-known pests. The preliminary sorting of these materials has first to be done in the laboratory, and suitable testing methods have been worked out and are still being developed for this purpose. These laboratory methods are also employed, in the first place at any rate, in an attempt to correlate insecticidal action with chemical and physical properties, a line of research that is more fully dealt with later on since it can more conveniently be discussed from a chemical than from a biological standpoint. Finally, the investigation of the physiological action of insecticides is now receiving attention through the co-operation of workers at the Imperial College of Science and Technology.

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CHEMICAL INVESTIGATIONS

(By H. Shaw)

The investigations undertaken by the Chemistry Section at East Malling can conveniently be considered under three headings, namely, routine analysis, routine research, and fundamental, long-range investigations. Routine analysis calls for no more than passing comment. It consists largely of the examination of commercial preparations, usually for the purpose of determining the nature and amount of active constituents.

Spray Compatibility.

Routine research comprises in the main the investigation of problems encountered in the practical application of pest and disease control measures. Outstanding among these is the question of the compatibility of spray ingredients. It often happens that a mixture of substances, highly desirable from the point of view of control measures, cannot be used because of the chemical interactions that take place between the several ingredients. In some cases, such reactions alter the properties of the constituents so radically as to render the particular mixture quite impracticable, notable examples are lime-sulphur or Bordeaux mixture and soap. In other cases, e.g. lime-sulphur and lead arsenate, despite the obvious reaction that occurs between the components, the spray is in widespread use, usually with more or less damage to the trees. This mixture has been the subject of detailed investigation with a view to ascertaining the mechanism of the phytocidal action and to the elimination, if possible, of this undesirable property. The damage appears to be composite, due in part to sulphur and in part to soluble arsenic. It has been shown that this latter constituent of the wash decreases as the proportion of lime-sulphur to lead arsenate increases, i.e. the more lime-sulphur that is

added to a constant amount of lead arsenate, the less the amount of soluble arsenic produced. On the other hand, damage due to sulphur increases directly with the concentration of lime-sulphur. Just what is the optimum balance between the two components, and whether or not the damage can be reduced by the addition of other substances, such as lime, are for further experiments to show. Ferrous sulphate, a substance that has been proposed as a "safener" for this wash, has not proved satisfactory in practice under our conditions.

Spray Residues.

Another investigation of immediate practical importance is the determination of spray residues. The method elaborated for the simultaneous control of Cane Spot and Raspberry Beetle on raspberry and loganberry, namely the derris-lime-sulphur spray, has proved unsatisfactory in that the residue of sulphur on the berries is objectionable when the fruit is to be canned. Copper fungicides have now been substituted for the lime-sulphur and our experiments have shown that the amount of copper remaining on the fruit when picked is quite innocuous.

The increase in recent years of the Codling Moth has rendered desirable later applications of lead arsenate. The biological factors suggest that the end of June is the most opportune time for spraying, and immediately the question arises, how late can lead arsenate be applied without exceeding the amount of arsenical residue permissible at picking time? Our results show that hard fruits may safely be sprayed with normal amounts of lead arsenate up to six weeks before picking, but not later than mid-July even in the case of later varieties.

This same series of experiments has been used to examine the effect of the inclusion of supplements in the wash on the deposit and retention of lead arsenate. It has been shown that the effect of wetting and spreading agents is negligible, but the addition of an emulsion of refined petroleum oil increases the initial deposit of solid and improves the retention of the residue.

Properties of Sprays.

Our experiments of a more fundamental nature have been designed to elucidate the mechanism of the action of certain insecticides and fungicides, to establish as far as possible the relation between chemical and physical properties on the one hand and insecticidal and fungicidal properties on the other, and to conduct, largely on the basis of the information so acquired, a rational search for new and improved agents for plant protection. Before any progress was possible in this work, it was necessary to elaborate methods for the critical biological testing in the laboratory of insecticides and fungicides. The achievements in this direction have already been mentioned and we now have available a fairly satisfactory range of adequate methods.

Tar and Mineral Oils.

In this country, tar and mineral oil sprays have been in regular use as winter ovicides for upwards of ten years. Until fairly recently they have been used more or less empirically, since little was known of their mode of action or of the nature of the effective constituents. Since 1934 an intensive investigation of these factors has been in progress at East Malling. In its inception, the work was designed to explore the possibilities as an ovicide of the tar oil which is a by-product of the manufacture of smokeless fuel, i.e. low-temperature tar distillate. The investigation quickly developed into a survey of the whole range of hydrocarbon oils, namely tar distillate oils produced by all the usual methods of carbonization, mineral oils both partially and highly refined,

and the hydrogenation products of certain tar distillates. The neutral portion of each of these oils has been split up into numerous fractions, according to boiling range, and the chemical and physical properties of each fraction determined. Using the methods previously mentioned, all these fractions have been evaluated as ovicides and we are now attempting to correlate the two sets of properties.

It has been suggested by other workers that the content of high-boiling, neutral, aromatic oil, as determined by solubility in dimethyl sulphate, is a satisfactory index of the toxic properties of any tar-distillate preparation to the eggs of Aphis and Apple Sucker. We have shown this to be true only when the tar oil used is of the anthracene oil type. With low-temperature tar oils and especially with hydrogenation products, there is a very wide divergence. The results obtained have proved to be of such a complex nature that it has so far been quite impossible to establish or even to suggest a correlation of properties that will hold throughout the range of oil types. In the case of Winter Moth, it appears that boiling range is the principal factor in determining ovicidal action. While this by no means accounts for all the differences between the various oils, it is broadly true that the higher the boiling range, the greater is the ovicidal power.

All these experiments provide an opportunity to study the mechanism of the ovicidal action of the hydrocarbon oils. It has long been known that tar and petroleum oils behave very differently, for while the former will control Aphis and Apple Sucker but have little effect on Apple Capsid and Red Spider, the action of the petroleum oils is exactly the reverse. It has been supposed that the explanation of this phenomenon is that the tar oils exert a chemical toxicity whereas the petroleum oils are effective by reason of a physical action. The correctness of this hypothesis has, however, never been conclusively demonstrated.

New Spray Materials.

When we turn to the perpetual search for new and more effective means of crop protection, it is obvious that there has been a marked trend in recent years towards the use of organic substances, whether of vegetable origin, e.g. derris and pyrethrum, or the products of chemical synthesis. Perhaps the strongest influence in this direction, certainly in the case of insecticides, is the desirability of avoiding as far as possible toxic residues on the picked fruit. A notable example already quoted is the use of derris to control Raspberry Beetle in circumstances where any poisonous spray is inadmissible. Another interesting potential use of organic compounds is as supplements to winter petroleum sprays. The difference in action of tar and petroleum sprays entails the use of both for the winter control of common orchard pests, and clearly it would be an advantage if some material could be included in the one to exclude the necessity for the use of the other. The most promising line seems to be the addition to the petroleum wash of substances capable of controlling Aphis and Apple Sucker. Of the many materials tested in the laboratory, 3 : 5-dinitro-*o*-cresol, dodecyl thiocyanate, β-butoxy-β'-thiocyanodiethyl ether, and nicotine have proved most effective for this purpose and these have been included in field trials. There, the dinitrocresol in particular and the other materials to a lesser extent have maintained their promise and the trial is being continued.

In the case of fungicides, the attraction of synthetic chemicals lies in the possibility they offer of avoiding the damage to the crops that has so far proved inseparable from the use of inorganic fungicides. Several such compounds gave promising results in the laboratory, and of these, tetramethylthiuram disulphide maintained some promise when used in a field trial.

The results of many of the laboratory tests have, at present, an academic interest only. We are, however, steadily building up our knowledge of the relation between chemical structure and insecticidal and fungicidal properties. As examples in passing, we have been able to show that tetramethylthiuram disulphide is about ten times as toxic to the spores of Apple Scab as is tetramethylthiuram monosulphide; *normal* dodecyl thiocyanate is much more active, both as an ovicide and as a contact insecticide, than its near relatives cetyl thiocyanate and *secondary* dodecyl thiocyanate; whilst 3 : 5-dinitro-*o*-cresol is a more effective ovicide than is 2 : 4-dinitrophenol from which it differs only by the addition of one methyl group in the molecule. The significance of such facts as these will be fully appreciated, for they make possible a systematic and enlightened search for new materials, in contrast with the haphazard, hit-or-miss methods that have in the past been the only possible method of approach.

Summary.

An outline is given of experiments carried out in recent years on the control of such pests or diseases as Apple Scab, Pear Scab, Brown Rot, Bacterial Canker and Shot-Hole, Branch-Blister, Fusarium Bud-Rot, Strawberry Mildew, Raspberry Beetle, Apple Sawfly, Apple Blossom Weevil, and Codling Moth.

Better control and less spray damage have been aimed at through the modification of existing spray mixtures and schedules, the consideration of constitutional and environmental factors, and the chemical study of spray compatibility, and by a search for new fungicides and insecticides.

Laboratory methods of testing have been evolved. These facilitate the survey of new materials and are essential to the attempts now being made to correlate fungicidal and insecticidal action with chemical and physical properties.

SPRAY RESIDUES ON FRUIT*

By H. SHAW

Like the poor, pests and diseases of fruit trees are always with us, and one of the major preoccupations of the fruitgrower is the circumvention of the mighty army of parasites that is all too eager to share with him the fruits, if any, of his labours. It is in these conditions that the science and practice of crop protection have evolved.

The methods adopted for the control of orchard pests and diseases are many and various, conditioned by biological, seasonal, and environmental factors. Broadly, however, they can be regarded as of two main types, eradicant measures designed to extirpate parasites already in possession of the host plant, and protective measures elaborated as a defence against potential attacks by insects and fungi.

The agents principally used as eradicants are egg-killing washes, notably the tar distillate and mineral oil washes, contact insecticides like nicotine, pyrethrum, and quassia, and a few contact fungicides. As these substances depend upon a direct rather than a residual effect, they do not come within the scope of our present considerations. On the contrary, the protective insecticides and fungicides act by virtue of their persistence upon the leaves and fruit of the plant and only in so far as the protective deposit is maintained are they effective. In consequence it is here that the question of spray residue sometimes becomes acute.

The problem takes on several forms, and residues may be objectionable for a variety of reasons. I propose to illustrate these by examples drawn from our own experience at East Malling.

The important soft fruits of the raspberry-loganberry group are subject to serious attack by the Raspberry Beetle (*Byturus tomentosus* Fabr.) and by the Cane Spot fungus (*Elsinoë veneta*). The grubs of the Raspberry Beetle hatch out only a week or two before the fruit is ripe and, in the absence of satisfactory measures for controlling the pest in other stages, it has been shown that the best control is obtained by spraying within a week or so of picking (4). Clearly this rules out all poisonous materials such as lead arsenate, and an alternative was sought in the non-poisonous vegetable insecticides. Pyrethrum proved to be of little value, but an entirely satisfactory control was obtained by the use of derris (4). For reasons of economy, it was desired to include the fungicide to control Cane Spot along with the insecticide. Bordeaux mixture proved to be a highly efficient fungicide, but its use had to be abandoned because the berries were completely disfigured by the residue. Lime-sulphur was then tried as a substitute, and although a slight film of deposit was visible on the fruits, this was not regarded as of great importance. Reports from canners, however, drew attention to the deleterious effects produced on the cans by berries carrying a residue of sulphur.

This particular difficulty could be avoided by earlier application of the lime-sulphur, a procedure to which no exception could be taken on biological grounds (1), but only at the cost of an additional spraying. It was, therefore, desirable to find an alternative fungicide that could still be used in conjunction with the derris wash. Such a material was found in another copper compound, basic copper chloride (copper oxychloride) which, while giving a satisfactory control of the disease, suffered from none of the disadvantages

* An address delivered before the Food Group of the Society of Chemical Industry, reprinted from Chemistry and Industry, 1939, **58,** 65, by permission of the Editor.

mentioned above (5). The amount of copper on the picked fruit was so small as to be negligible (2). The mixed derris-copper oxychloride wash, therefore, is now likely to become recognized as the standard combined treatment for Raspberry Beetle and Cane Spot.

The same problem of sulphur residue has also been encountered on strawberries. It is customary to dust the plants with sulphur at frequent intervals to control Strawberry Mildew (*Sphaerotheca Humuli*) and Red Spider (*Tetranychus telarius* L.). In order, however, to avoid a troublesome sulphur residue on fruit intended for canning, the treatment is interrupted for a suitable time before picking.

It is perhaps not generally known that almost every apple exported to Great Britain from the United States of America has been washed in hydrochloric acid. It was pointed out some years ago by the authorities in Liverpool that fruit entering this country from the U.S.A. carried much more than the permitted amount of arsenical residue. This state of affairs was the direct outcome of the activities of the Codling Moth (*Cydia pomonella* L.). In order to control this pest under the hot, dry conditions of parts of the U.S.A., repeated applications of lead arsenate are necessary, and, in order to increase the density and persistence of the deposit, it is a common practice to include mineral oil in the wash. This results in the picked fruit carrying an amount of arsenic very much in excess of that permitted. It was to remove this residue that the acid washing was introduced. In this country, fortunately, we have not yet approached this state of affairs, but the increase in recent years of the severity of the attacks of Codling Moth has compelled us to take into account a very unwelcome possibility. The first step was to determine how late in the season lead arsenate could be applied to the trees without exceeding 0·01 grain of As_2O_3 per pound on the picked fruit. Biological considerations suggest that the end of June is about the best time to apply the spray in a normal year (6). Chemical analyses, on the other hand, showed that normal amounts of lead arsenate may safely be applied up to six weeks before picking time but not in any case much later than mid-July (2). Actually it is preferred not to apply the spray after the end of June, since in some seasons an unsightly deposit may remain on the picked fruit even though the permitted amount is not exceeded. Thus all varieties of apples can be sprayed at the optimum time for Codling Moth control, but occasionally such early varieties as Beauty of Bath, Early Victoria and Grenadier may need to be wiped before marketing. In the light of this situation, any non-toxic insecticide capable of replacing lead arsenate would be highly welcome. Actually, at the moment, the American authorities are much more concerned about the residue of lead than about arsenic. Consequently calcium arsenate has come into widespread use, but it suffers practical disadvantages as compared with lead arsenate. Silicofluorides have also been used, but the occurrence of several cases of fluorine poisoning has placed these materials out of court. A more promising line of approach is the application of synthetic organic chemicals, one at least of which, phenothiazine (thiodiphenylamine), has shown sufficient promise (3) to merit extended field trial in the United States. Unfortunately, control of the pest was very variable, some spotting of the fruit occurred and there is some evidence that size and colour were adversely affected. Consequently, the use of this substance, although still under investigation, is not now considered very hopeful. So this particular problem, one of the most urgent confronting the fruitgrower, remains unsolved.

These examples bring out the several objections to spray residues on the ground of (*a*) their toxicity, (*b*) their deleterious influence in the subsequent processing of the fruit, and (*c*) their objectionable appearance. They also indicate the lines along which the problem may be approached. As far as the biological factors allow, the timing of the spray application may be altered. Better still, it is sometimes possible to devise

a method for the control of a pest at some other stage of its development. Alternatively it is sometimes possible to substitute a non-poisonous insecticide or fungicide. Perhaps the brightest hope for the ultimate solution of this troublesome problem lies in the extended use of the vegetable insecticides and the introduction of new substances from the very wide range of synthetic chemicals that is the subject of intensive investigation at the present time.

Summary.

Problems associated with spray residues on fruit trees are illustrated from experiences at East Malling Research Station. Derris and copper oxychloride are now used in preference to lead arsenate and lime-sulphur to control Raspberry Beetle and Cane Spot on raspberries, etc., so as to avoid a residue that might be harmful to the consumer or objectionable to the canner. The timing of the lead arsenate spray to control Codling Moth on apples has been so adjusted that the residue at picking time does not exceed the tolerated maximum. The general principles applied in avoiding objectionable residues are discussed.

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APPLE SCAB CONTROL

THE PROBLEM, AND SOME RECENT RESEARCH FINDINGS AS REGARDS ITS SOLUTION*

By M. H. MOORE

Apple growers, and particularly those in the south-eastern counties, may find it helpful to have a summary of the results of experiments on Scab control carried out at East Malling Research Station in recent years, and that is the purpose of this article.

It cannot be emphasized too much that spraying must be *protective* to give the best results. All kinds of difficult problems arise when the disease is allowed to get going before efforts are made to stop it. In practice it is not always easy to avoid this, but an intelligent understanding of the normal behaviour of the Scab fungus is a great help towards controlling the disease it causes.

Sources of Infection for the Trees.

There are two : (1) the previous year's dead, scabbed leaves lying on the ground, and (2) the " pustules " on the young shoots and buds of certain susceptible varieties, notably Cox's Orange Pippin and Worcester Pearmain. In the writer's opinion, the first of these is much the more important because its influence is widespread while that of the second is localized even within any one plantation. From the dead leaves, spores that are much too small to be visible to the naked eye are shot into the air sometime during the period between bud-burst and flowering of the apple trees. It will be seen later that the period of discharge does not vary greatly from year to year, and is usually at mid-April or a little later, when the trees are at the " green-bud " stage. These tiny spores (winter spores) are very light indeed and are caught up and whirled through the plantation even when the air movement is only very slight. They can probably be carried immense distances in the wind. This is an important point because it means that the sources of infection for any grower's trees are not necessarily within the confines of his own or even his neighbour's plantations. Naturally if his own dead leaves are very scabby there is more chance of the spores alighting on his own than on a neighbour's trees first, but it does not follow that if his own dead leaves are free from Scab his trees are not likely to become infected. It is a very different matter with the spores produced in pustules on the young shoots and bud scales. These spores, although of the same fungus, are of a different kind ; they are not shot into the air, but are removed by rain and perhaps to some extent by insects. They alight on the new leaves by being splashed there in rain drops or by being washed over the opening buds by rain running down the twig. Hence this source of infection is likely to affect mainly the tree on which it occurs and neighbouring trees to only a limited extent.

* Reprinted by courtesy of *The Fruitgrower* 13th April, 1939, **87**, 569-70.

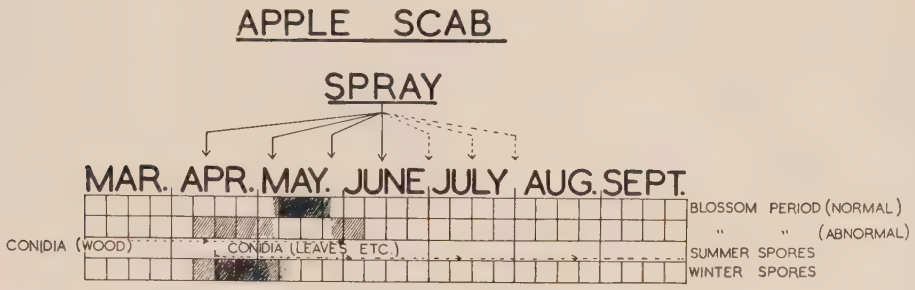
The same is true of the spores produced on a fresh Scab spot in spring. When a spore from a dead leaf on the ground alights on a young leaf on the tree in, say, April, it grows if the conditions are favourable, and in 8-10 days has produced the visible brown Scab spot familiar to all apple growers. On this spot, summer spores are produced that are unlike the original but are the same type as those produced in the wood pustules. They, too, are not shot into the air, but are splashed about by rain, and in their turn produce similar Scab-spots on other leaves. So it comes about that once the dead leaves have finished shooting out their spores there is no source of infection for a tree other than that already existing on it, apart from the few spores that might be carried from a nearby infected tree in wind-blown rain. If the spores from the dead leaves are prevented from causing infection on trees already free from pustules on the young shoots and buds, therefore, the Scab problem is virtually solved. A thorough grasp of this point is the crux of the intelligent application of control measures. The grower cannot, as far as we know, prevent the winter spores from being shot into the air. Even if he buries most of the leaves it is likely that there will still be enough caught up at the bottoms of fences and other obstructions to give the disease a good start in spring, though the ploughing in of some of the leaves does admittedly reduce the number of sources of infection. He can, however, prevent infection by coating the leaves *before the spores get there* with a suitable fungicide, and that is the object of the spring spraying programme. It will be appreciated from what has already been written that the period during which the winter spores are shot out is easily the most critical of the season as regards Scab. Sometimes conditions unfavourable for infection, such as a dry spell, occur in spring (Scab thrives in wet, cool weather) and many of the spores die, but the grower cannot afford to rely on that. Spraying is his safeguard and every spore prevented from causing infection in spring means literally thousands less to deal with later at a very much more awkward time, that is, during or after blossom.

The Importance of Timing the Early Sprays Correctly.

Observations on this very critical period have been made for several seasons at East Malling by studying the time at which the main discharge of winter spores from the dead leaves occurs. The state of development of the trees at this time is very important and may influence the success or failure of the spraying programme. This will be seen by a glance at the accompanying chart (summer spores are referred to as *conidia*).

Seasonal variation evidently concerns the tree much more than the fungus, and it is an interesting and very practical point that the tree is more likely to be responsible for a breakdown in the grower's plans than is the fungus, which appears to be surprisingly constant in its habits. The third week of April is obviously " zero hour " more often than not, and only occasionally does danger threaten earlier than that. It would be unwise, however, to wait until the third week of April before putting on the first spray for Scab. It takes time to " get round ", and two or three days may be lost through bad weather for spraying. Moreover, one has to guard against the possibility of a small proportion of spores ripening earlier than the others and being shot out a few days before the main barrage begins. This does, in fact, frequently happen. On the other hand, it is not good policy to put the spray on long before these spores are ripe because for one thing there is practically no leaf on the tree to hold the spray and, furthermore, the deposit of spray daily becomes less fresh and therefore less effective. In the writer's opinion the first application should be begun, allowing a reasonable margin for bad weather, to ensure that all the trees have been sprayed by roughly the

middle of April, when, on the average, apple trees will be approximately at the " green-bud " stage (flower buds in a tight cluster and surrounded by half expanded leaves). It is very important that this application be very thoroughly done, for so much depends upon its thoroughness. If a grower finds that, for some good reason or other, he is a few days late he need not despair, for there is a very good chance that a few early spores not yet properly established on the foliage will be killed when the spray falls on them. It is bad policy to rely on that, but occasionally it cannot well be avoided, especially during a spell of bad weather. Another application should be made just before blossom, again calculated for completion at " pink-bud ", that is, as near blossom time as possible. This will do much to protect the trees during the blossom period when, as far as we know at present, they cannot safely be sprayed with fungicide.



	YEAR	BEGINNING OF MAIN DISCHARGE OF WINTER SPORES.	PINK-BUD IN COX'S O. P.	
	1930	3rd week in April	9th. May	
	1931	3rd. " " "	4th "	
ABNORMAL	1932	3rd. " " "	18th. "	LATE
ABNORMAL	1933	End of April	21st. April	EARLY
	1934	End " "	4th. May	
	1935	2nd. week in April	1st. "	
	1936	3rd " "	5th. "	
	1937	3rd. " "	4th. "	
ABNORMAL	1938	3rd. " "	8th. April	EARLY

It should be clearly understood here that, so far, only a " normal " season, that is, when " pink-bud " occurs during the first few days of May, has been considered. Abnormal seasons occurred in 1932, 1933, and 1938, the abnormality being due to the influence of weather conditions *on the tree*. In 1932, for instance, a period of cold, wet, sunless weather after bud-burst delayed the development of the blossom trusses and their surrounding leaves, and though the winter spores were shot out during the third week of April the trees had not reached the green-bud stage. Pink-bud was not until the middle of May so that there was a period of roughly three weeks between the first and second pre-blossom spray applications. This is too long to leave the trees unsprayed at this critical period and an extra pre-blossom spray could, with advantage, have been

given between the first and that at pink-bud. In 1933 and 1938, however, pre-blossom applications were of much less relative importance, for these seasons, especially 1938, were " early " ones. The main discharge of winter spores coincided with the blossom period and *this appears to be the chief unavoidable cause of failure of the spray programme*. In such circumstances the grower can do little but rely on the efficacy of the pre-blossom spray-treatment. If the weather is favourable for flowering and the blossom period is consequently short there is relatively little danger. The trouble comes when the blossom period is prolonged by unfavourable weather as it was in 1938 when there was no Scab-infection up to blossom time, but when it occurred and developed very rapidly while the trees were in bloom.

Spraying in Bloom and Manurial Treatment.

Experiments are under way to test the effect on the blossoms and on Scab of weak fungicides applied during the blossom period. Their possible influence on biennial bearing is also being studied. Another promising line of attack lies in suitable manuring to increase the resistance of the trees to infection, thus enabling them the better to withstand a fairly long period without spray treatment. This is being followed up experimentally, but this problem is very complex because there are so many factors to be considered. There are indications that excess nitrogen promotes conditions favourable for infection and that potash is a useful corrective, but it is not possible at present confidently to go further than that, for the study is as yet in its infancy. The influence of manurial treatment on spray damage is also being studied.

Neglected Plantations.

Where such plantations contain varieties susceptible to "wood" infection, a special case arises that calls for special treatment. The spores in "wood" pustules often ripen much earlier than the winter spores in the dead leaves, and can cause infection as soon as new leaves appear, provided the weather is favourable for it. In such circumstances it would be wise to apply the first pre-blossom spray soon after bud-burst when the young curled leaves each resemble a mouse's ear—the so-called " mouse-ear " stage. This occurs early in April in a " normal " season. Where trees have been regularly and well sprayed for Scab, "wood" infection should not exist, even on varieties susceptible to it, and the need for this very early spray does not then arise.

Methods of Spraying and Choice of Fungicide.

On the chart, at the top, are arrows showing the suggested times for applying protective sprays. The continuous arrows represent the important applications, and the dotted ones those that may be necessary if the earlier ones have not been entirely successful. It is well known that trees should not be sprayed with strong fungicides after blossom because of the risk of spray damage. If Scab has not been controlled by the end of May, therefore, it is difficult to keep it in check by post-blossom applications that must necessarily be weak. Modern spraying machinery and methods, by making possible the use of high pressure and spray output, have greatly increased the speed of spraying. This is obviously a great boon where it is essential, as in Scab-control, to cover all new growth in the shortest possible time. In the earlier days of spraying it was customary to use much stronger mixtures than those in use today, probably because, since only low pressures and outputs were then available, it was found safe to use stronger sprays, and desirable to have them because the trees could not be sprayed as often as they can now. Undoubtedly " weaker and more frequently " is better policy

than " stronger and less frequently ", because new growth is rapid early in the season and leaves, shoots, etc., should not remain unprotected while there is a risk of infection. It has been proved by experiment that heavy application of driving sprays is more conducive to spray damage than light, less forceful application, but, if only for the sake of necessary speed, it would not be wise to discard the modern methods on that account. It is possible also that trees are more susceptible to spray damage than they used to be, for more is now demanded of them, thus necessitating closer attention to their nutritional requirements. The evident solution is to reduce the strength of sprays, and this, coupled with their more frequent application, is proving successful in practice. Sprays containing copper are of doubtful safety on apple trees and they are probably best avoided either until a safe, effective form is found or until further research brings to light some means of altering the condition of the trees so that copper sprays can safely be used. Lime-sulphur is the most widely used spray for Scab, and provided the early applications are well timed and thoroughly made, 2½% is strong enough pre-blossom. Excellent Scab control has been given in experiments where even 1% was used pre-blossom, but where a stronger spray up to 2½% is safe it is wise to use it. The 1% spray is rather near the effective limit of lime-sulphur, and special care would have to be taken to ensure very thorough application. If, as in 1938, the period that elapses between green-bud and pink-bud is very short and 2½% has already been applied at green-bud, the spray can be weakened at pink-bud to avoid the risk of burning the rosette leaves ; 1½% should then be sufficient. After blossom certain varieties in most districts need not be sprayed with fungicide for they are resistant to Scab and some are, in addition, sulphur-shy. Such varieties include Stirling Castle (omit also pre-blossom), Lane's Prince Albert, Duchess Favourite, Lord Derby, Edward VII, Charles Ross, Gladstone, Early Victoria (Emneth Early), Beauty of Bath, Rival, Grenadier, Belle de Boskoop, and St. Cecilia. Most other varieties can be sprayed with lime-sulphur at 1% at petal-fall, nicotine at 8 oz. per 100 gallons being included for Sawfly. One, or at most two subsequent sprays at fortnightly intervals should prove sufficient if the earlier sprays have done their job satisfactorily. In some districts 1% can safely be used for each of these ; in others ¾% or even ½% may have to be resorted to for safety. Colloidal sulphur at 4 or 5 lb. per 100 gallons is a very useful alternative to lime-sulphur for these post-petal-fall applications, and it seems reasonably safe on all but the more sulphur-shy varieties. Its drawback in comparison with lime-sulphur is its cost. Little can at present be said of the new wettable sulphurs, but they are being extensively tried this season and opinion will doubtless be more informed about them in due course.

SPREADERS.

Experiments have shown that the addition of a spreader to lime-sulphur does not appreciably increase Scab control *provided that the spray-treatment is protective.* Where, however, infection is already " on the run " post-blossom, the inclusion of a good spreader might be an asset in helping the weak fungicide to reach the Scab spots and wet them, thus sterilizing the spores on the surface of the spots and, possibly, drying them up. This is eradicant as opposed to protective action, that is, it is designed to destroy disease already on the tree as opposed to preventing its getting there. Dependence on eradicant measures on the foliage and fruit, as far as Scab is concerned, is deprecated and to be avoided wherever possible.

ARSENATE.

Where tar and petroleum oil have been applied the addition of arsenate to the fungicide may be unnecessary. If there is a risk of caterpillar damage, however, arsenate,

as lead arsenate paste, 4 lb. per 100 gal. or as powder, 2 lb., can be added to the lime-sulphur used at green-bud.

Summary.

The sources of Scab infection are discussed in relation to their bearing on the season's spraying programme. It is shown that "early" or "late" seasons may be responsible for failure to control Scab. The importance of correct timing and thorough application of the early sprays is emphasized, and recommendations are made for controlling the disease.

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